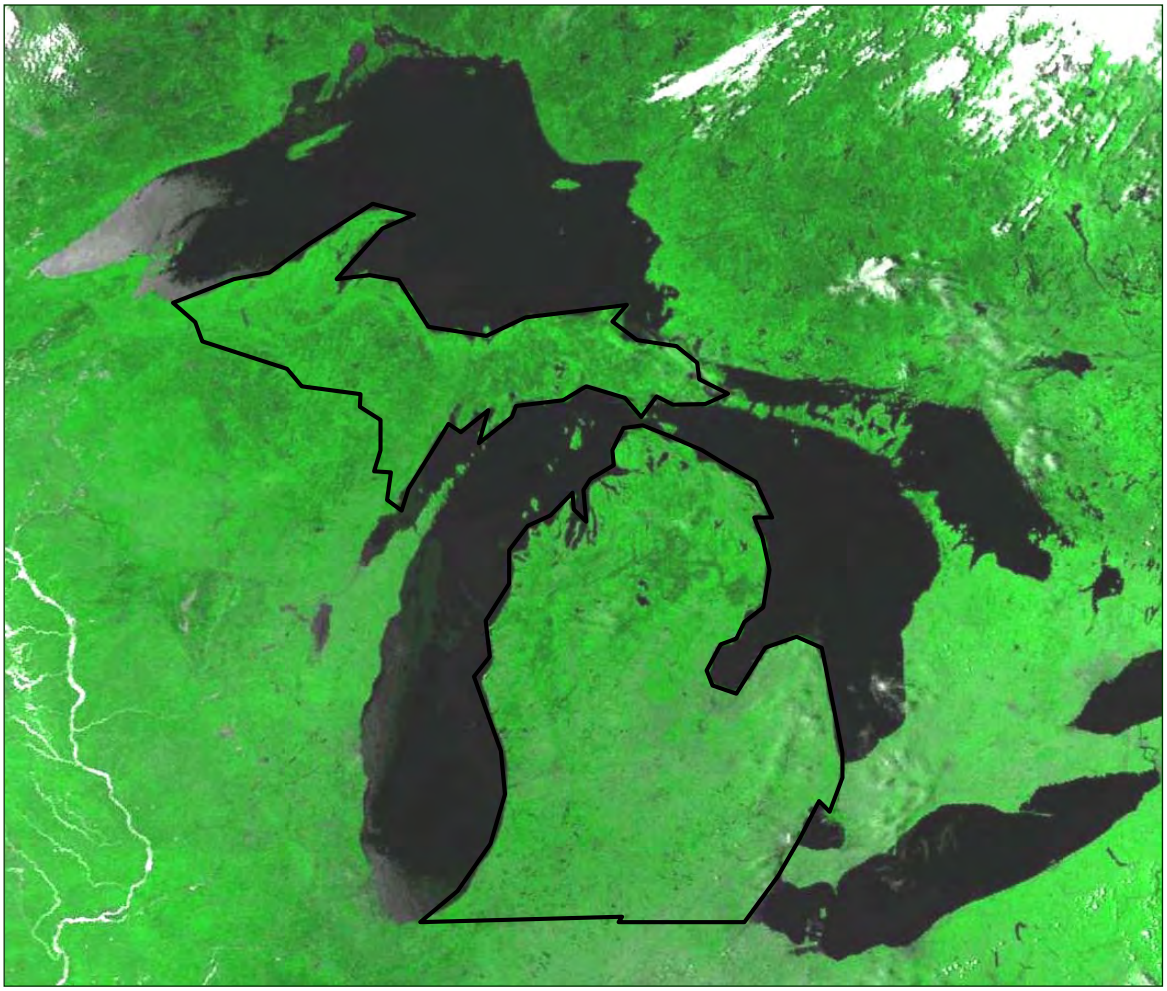
MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
MERCURY STRATEGY STAFF REPORT

MDEQ'S CURRENT STATUS AND RECOMMENDED FUTURE ACTIVITIES TOWARD THE GOAL OF ELIMINATING ANTHROPOGENIC MERCURY USE AND RELEASES IN MICHIGAN



STATE OF MICHIGAN • JENNIFER M. GRANHOLM, GOVERNOR
MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY • STEVEN E. CHESTER, DIRECTOR
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JANUARY 3, 2008

STEVEN E. CHESTER
DIRECTOR

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MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY

INTEROFFICE COMMUNICATION

TO: Steven E. Chester, Director

FROM: Joy Taylor Morgan, Air Quality Division
Steve Kratzer, Environmental Science and Services Division
(Co-Chairs of MDEQ Mercury Strategy Workgroup)

DATE: January 3, 2008

SUBJECT: MDEQ Mercury Strategy Staff Report

In response to your request, we have developed the attached MDEQ Mercury Strategy Staff Report (Report) that provides a comprehensive framework to guide the MDEQ's efforts toward eliminating the use and release of anthropogenic mercury.

As highlighted in the Report, Michigan has made significant progress in reducing the use and release of anthropogenic mercury. The Report guides further multimedia efforts to eliminate mercury and ensure the protection of Michigan's citizens and wildlife from this persistent toxic pollutant. Included are 67 recommendations calling for specific activities to identify, monitor, and control mercury. The Mercury Strategy Workgroup identified 10 priority activities which, if implemented, would result in the most significant mercury reductions in Michigan. The Report also offers information and outreach efforts to further encourage elimination of mercury use, and includes specific steps for the adoption of comprehensive mercury legislation for Michigan.

Implementation of the specific activities identified requires ongoing collaboration and participation with Michigan stakeholders. We therefore recommend seeking input from stakeholders on this Report to assist in setting priorities for achievement, developing implementation plans, and encouraging partnerships.

Attachment
cc: Jim Sygo, Deputy Director
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ACKNOWLEDGMENTS

This report was prepared by the Michigan Department of Environmental Quality (MDEQ) Mercury Strategy Workgroup (MSWG). The MSWG is a team of staff representing multi-media programs in the MDEQ. MSWG participants include staff from the MDEQ's Air Quality Division (AQD), Environmental Science and Services Division (ESSD), Remediation and Redevelopment Division (RRD), Waste and Hazardous Material Division (WHMD), and Water Bureau (WB). The following lists the MSWG participants and their respective divisions:

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The MSWG wishes to acknowledge **Brendan Boyle**, Public Health Specialist, Michigan Department of Community Health (MDCH) as an important contributor to the workgroup, **Sheila Blais**, AQD Department Analyst, for her editorial contributions and expertise in finalizing this report, and **Leah Granke**, a former AQD employee. The MSWG also would like to acknowledge **Alexis Cain**, Environmental Scientist for the U.S. Environmental Protection Agency (EPA) Region 5, and **Tom Metzner**, Environmental Analyst with the Connecticut Department of Environmental Protection, as well as numerous MDEQ staff for their review and input to this Report.

After the members were selected by MDEQ Division Chiefs and the WB Chief, the MDEQ Director sent out an interoffice communication to his staff highlighting the importance of the mercury issue and sharing the charge of the MSWG on January 11, 2006 (see **Appendix B**). The MSWG was charged by the MDEQ Director with evaluating current sources, monitoring activities, rules and policies, and developing a strategy with specific recommendations toward a goal of eliminating anthropogenic mercury [use and] releases in Michigan within a specified time frame.

It is important to note that following convening of the MSWG and in addition to the finalization of this MDEQ Mercury Strategy Staff Report, MSWG participants were able to achieve numerous other mercury-related accomplishments concurrent with its deliberation as part of their daily responsibilities. These activities demonstrate the ongoing mercury reduction efforts in the state. More details regarding these accomplishments are included in **Appendix V**.

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Michigan Department of Environmental Quality

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EXECUTIVE SUMMARY

The Michigan Department of Environmental Quality's (MDEQ's) Mercury Strategy Workgroup (MSWG) was convened in January of 2006 following a directive from MDEQ Director Steven E. Chester to develop "consistent priorities and goals related to mercury policies, regulations, legislation, monitoring, sources, and outreach efforts." (See **Appendix B** for the Director's memo.)

The MSWG is a team of MDEQ staff representing multi-media mercury programs that was given the charge to develop a comprehensive strategy to eliminate mercury contamination in Michigan's environment by identifying current sources, monitoring activities, policies and regulations and to make specific recommendations to meet the goal of eliminating anthropogenic mercury use and releases in Michigan within a specified time frame.

The specific charge from the MDEQ Director to the MSWG was to:

1. Establish an effective communication process to ensure that efficient cross-divisional communication on mercury issues occurs with the MDEQ (such as utilizing the Intranet Team Rooms).
2. Identify current MDEQ policy initiatives and activities related to mercury reduction, monitoring, and environmental release information from each participating division.
3. Evaluate how existing programs can be improved, including through cross-divisional cooperation.
4. Present priority policy initiatives and activities (current and anticipated) from each division.
5. Prioritize policy initiatives and activities (current and anticipated) for the MDEQ, emphasizing cross-divisional cooperation on actions and initiatives.
6. Draft recommendations to the MDEQ Director on future activities, programs, policies, legislation, or regulations to address mercury use and releases to the environment, and obtain feedback and guidance from the Director's office.
7. Develop a MDEQ Mercury Strategy that outlines these recommendations with appropriate timelines that pursue the overall goal of virtually eliminating anthropogenic mercury use and releases to the environment.

The MSWG established an effective means of cross-divisional communication by setting up an Intranet team room and utilizing the MDEQ's U drive to share documents. Meetings on a regularly scheduled basis (twice per month) allowed the MSWG to effectively communicate and discuss various issues related to mercury. From January 31, 2006 through August 2007 the MSWG had approximately 38 meetings. During these meetings the MSWG developed a charter that included identifying their purpose, goals, and action steps needed to develop a comprehensive, effective mercury strategy for the MDEQ.

A summary of current regulations, policies and monitoring activities is included in the strategy. An inventory of recent mercury (Hg) releases was compiled for 2002. **Figure ES-1** identifies in pounds per year (lbs/yr) estimated known mercury releases (references are identified in **Table ES-1**).

FIGURE ES-1: TOTAL MERCURY RELEASES

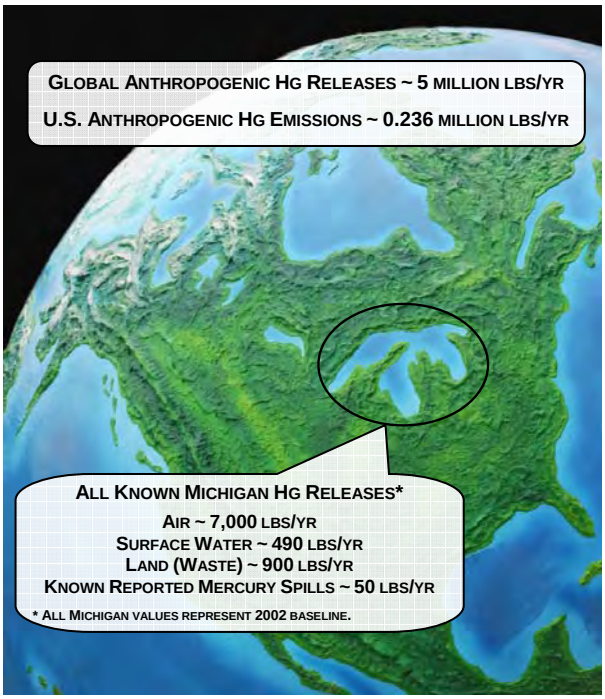


TABLE ES-1: ANTHROPOGENIC MERCURY RELEASES AND COLLECTION

SOURCE	AMOUNT	REFERENCE
MERCURY RELEASES		
Global Releases to Air	~ 5 Million lbs/yr (2,200 to 2,600 tons/yr)	Bergan et al., 1999; Mason and Sheu, 2002; Lamborg et al., 2002a; Seigneur et al., 2004
United States (U.S.) Releases	~ .0236 Million lbs/yr (110 tons/yr)	U.S. Environmental Protection Agency (EPA), 1997
Michigan Releases to Air	~ 7,000 lbs/yr	Granke, MDEQ Mercury Emissions Inventory 2002 (see **Chapter 2**)
Michigan Surface Water Releases	~ 490 lbs/yr	Toxics Release Inventory, 2002; Annual Waste Report, 2002 (Note: Significant uncertainties exist for this data)
Michigan Land (Waste) Releases	~ 900 lbs/yr	Waste Data System, U151 Mercury Waste Generated in Michigan. See **Chapter 2.4.1.**
2002 Known Reported Mercury Spills	~ 50 lbs/yr (~ 100 lbs/yr for 1999-2006)	See **Tables 2-20** and **2-21** in **Chapter 2.6**
COLLECTION OF MERCURY IN MICHIGAN		
Recycled Mercury from Clean Sweep Sites, 2003-2006	~ 1,156 lbs/yr (4,625 lbs total for 2003-2006)	Clean Sweep Annual Mercury Collection; Electronic Reports Submitted to MDEQ
School Collection Grants, 2004-2006	~ 980 lbs/yr *	MDEQ's Grant Information in **Chapter 4.2.8**

* Including elemental mercury and assuming all devices collected were laboratory thermometers containing ~3 grams of elemental mercury.

Following the finalization of the strategy and endorsement by the MDEQ Director, an implementation plan will be developed that includes creating appropriate baselines, specific recommendations or action items, and establishing a specific manager to track each action item, expected outcomes, and a specific deadline for completion of each task.

While the long-term goal is elimination of anthropogenic mercury use and releases to Michigan's environment, success of the strategy will be measured in various ways. Specifically, meeting designated water uses in the state, including water quality that will enable unrestricted fish consumption, is the primary means of measuring the success of the strategy. Other methods will include:

- tracking the overall emission reductions compared to a baseline,
- quantifying capture of mercury from products,
- meeting environmental guidelines or standards,
- measuring the decline of mercury spills and human exposure incidents, and
- documenting temporal or spatial trends of environmental indicators such as wet deposition and/or fish tissue data.

MSWG RECOMMENDATIONS

With input from MDEQ staff, the MSWG drafted recommendations that included 67 action steps (see **Chapter 9**) that if implemented, should successfully identify all known ***mercury uses*** and ***mercury releases***, and identify solutions that involve inventory, regulations and enforcement, collaborations and partnerships, education and outreach, and environmental monitoring to reach the long-term goal of ***eliminating*** anthropogenic use and releases of mercury to Michigan's environment. Additionally, there are 12 recommendations in **Chapter 3.7** that outline specific steps for adoption of comprehensive mercury legislation for Michigan.

THE MSWG RECOGNIZES THAT FOR THIS STRATEGY IMPLEMENTATION TO SUCCEED, THE MDEQ NEEDS TO ENSURE THAT THE MERCURY STRATEGY IS A PRIORITY AND THAT SUFFICIENT RESOURCES ARE DEDICATED TO THIS IMPORTANT MULTI-MEDIA CONCERN. RESOURCES SHOULD BE DEDICATED TO FULLY FUND THE NECESSARY STAFF IN EACH DIVISION AND/OR BUREAU WITH RESPONSIBILITIES TO TRACK, IMPLEMENT, AND EVALUATE PROGRESS UNDER MERCURY POLLUTANT MINIMIZATION PROGRAMS, MERCURY EDUCATION AND OUTREACH PROGRAMS, AS WELL AS MERCURY MONITORING AND EVALUATION PROGRAMS.

MSWG members used the following four criteria to identify 10 priority activities that if implemented would result in the most significant mercury reductions in Michigan:

1) Overall environmental release (quantity of release or impact to media),
2) Public health risks,
3) Efforts currently underway by international, national, state, local, and other organizations,
4) Available substitutes for mercury-added products.

Utilizing the four criteria above with the 67 drafted recommended action steps (see **Chapter 9**), the MSWG's top 10 priority recommendations for the MDEQ are to:

1) **DEVELOP AND MAINTAIN A RELIABLE BASELINE TO TRACK ALL MERCURY RELEASES FOR MEASURING SUCCESS.**
2) **REDUCE COAL-FIRED UTILITY RELEASES AND PAST CONTAMINATION FROM MERCURY LEGACY SITES ASSOCIATED WITH COAL-FIRED UTILITY PLANTS.**
3) **REDUCE PORTLAND CEMENT PLANT RELEASES AND PAST CONTAMINATION FROM MERCURY LEGACY SITES ASSOCIATED WITH PORTLAND CEMENT PLANTS.**
4) **CONTINUE TO IMPLEMENT ACTIVITIES THAT PHASE OUT MERCURY-ADDED PRODUCTS WHERE VIABLE ALTERNATIVES EXIST.**
5) **ENSURE THERE ARE SUFFICIENT FUNDS TO CLEAN UP LEGACY SITES AND GROUNDWATER CONTAMINATED BY MERCURY.**
6) **EXPAND EDUCATION AND OUTREACH TO THE PUBLIC, THE REGULATED COMMUNITY, AND MDEQ STAFF ON EXPOSURE OF MERCURY, SPILL CLEAN-UP, CONTROL TECHNOLOGIES, ETC.**
7) **EXPAND THE NETWORK TO COLLECT AND MANAGE THE DISPOSAL OF MERCURY-CONTAINING PRODUCTS (SUCH AS FLOURESCENT LIGHTS, SWITCHES, THERMOMETERS, BAROMETERS, ETC.) AND ELEMENTAL MERCURY (I.E. CLEAN SWEEP PROGRAM) IN MICHIGAN.**
8) **INVESTIGATE AND EXPLORE THE DEVELOPMENT OF A MECHANISM TO ENSURE THAT MERCURY COLLECTED OR RECOVERED IN MICHIGAN IS USED ONLY FOR ESSENTIAL USES. EXPLORE THE CURRENT BARRIERS REGARDING EXPORTATION OF NONESSENTIAL MERCURY USES TO OTHER STATES OR COUNTRIES.**
9) **PROMOTE A COMPREHENSIVE MERCURY STUDY THAT IDENTIFIES THE PROCESSES AND ECOSYSTEM CHARACTERISTICS THAT GOVERN THE MOVEMENT OF MERCURY FROM THE ATMOSPHERE, THROUGH AQUATIC ECOSYSTEMS AND WITHIN THE FOOD CHAIN AND IDENTIFIES SOURCE CONTRIBUTIONS.**
10) **CONTINUE NATIONAL/REGIONAL COORDINATION WITH THE QUICKSILVER CAUCUS AND ASSIST IN THE DEVELOPMENT OF A REGIONAL MERCURY EMISSION REDUCTION INITIATIVE SIMILAR TO THE GREAT LAKES MERCURY IN PRODUCTS PHASE-DOWN STRATEGY.**

This MSWG report provides an overview of the problem, the benefits and costs, and an estimate of the sources that contribute to mercury contamination in the state. It outlines Michigan's regulations and policies that address mercury and gives a summary of various activities implemented in the state to prevent the use and release of mercury. Control technology and remediation techniques are also included in this report.

Michigan's goal is to eliminate anthropogenic mercury use and releases to the environment. The desired end results are the removal of mercury-driven fish consumption advisories now in place and attainment of water quality standards (WQS) for the protection of human health and wildlife. The picture at right is an example of how a predatory piscivore's consumption can lead to biomagnification in the food chain.

Picture courtesy of the state of Alaska.

Therefore, the long-term goal of this strategy is to reduce the concern for the consumption of fish from Michigan's inland lakes, rivers and the Great Lakes as a result of mercury contamination and eliminate exposure to elemental mercury from spills, as well as to avoid impacting neighboring states and Canada from mercury transport and deposition.

1. BACKGROUND AND INTRODUCTION

1.1 BACKGROUND

Reducing human and wildlife exposure to mercury in Michigan continues to be a priority for Governor Jennifer M. Granholm as well as the MDEQ. Reducing mercury released into the atmosphere is a high priority since this is the major remaining, largely uncontrolled mercury discharge. Once mercury is released into the atmosphere, it can deposit to waterbodies, be converted to methylmercury (MeHg) and then bioaccumulate in fish. The concentration in fish can be as much as one million times higher than the surrounding surface water, so a small amount of mercury in the waterbodies can have significant impacts (Ullrich, et al., 2001).

The Michigan Department of Community Health (MDCH) continues to issue general fish consumption advisories for all of Michigan's 11,000 inland lakes along with specific recommendations for Lake Huron, Lake Michigan, and Lake Superior, 844 miles of Michigan's rivers and streams and for over 70 inland lakes due to MeHg concentrations in fish. MeHg contamination in fish is of particular concern for pregnant women, nursing mothers, women who may become pregnant, and young children. Applying Michigan 2000 census data to the Centers for Disease Control (CDC) data suggests that over 10,000 infants born in Michigan annually are potentially at risk for neurodevelopmental deficits due to MeHg exposure (CDC, 2004).

The reduction of mercury exposure in Michigan has been a key topic of the MDEQ for many years. The MDEQ has undertaken diverse activities in the state as a result of recommendations made by the Michigan Environmental Science Board (MESB, 1993) and the Michigan Mercury Pollution Prevention Task Force (M2P2 Task Force, 1996). Some of these efforts include reducing mercury usage in automobiles (manufacturing and salvage), dental offices, dairy farms (manometer usage), health care facilities and schools, and conducting mercury fever thermometer exchanges. The MDEQ has also worked diligently to reduce mercury air emissions from municipal and medical waste incinerators, automobile shredders, and electric arc furnaces (EAFs), and continues to actively work towards reducing mercury released to Michigan's waters through facilities' water discharge permits. In addition, the MDEQ has various environmental mercury monitoring efforts underway for air, water, sediments, and fish. Some of these activities were included in the *Michigan Mercury Action Plan* that was developed by the MDEQ, the MDCH, and the Michigan Public Service Commission (MPSC) in 1993 (see **Appendix C**). In 2002, the MDEQ put together a *Michigan Mercury Action Plan Progress Report* (see **Appendix D**). Currently, Michigan's mercury action plan is in need of review and updating. The formation of the MSWG served as the next step in evaluating the MDEQ's existing and future mercury reduction objectives.

After his appointment to the MDEQ in 2003, Director Chester selected mercury reduction as an area where Michigan should be a leader. Following discussions with MDEQ staff, the Director recommended that a benchmark group be established to review other states' mercury reduction activities, identify gaps in Michigan's activities, and pursue further efforts on mercury reduction. Shortly thereafter, the Quicksilver Caucus (QSC) undertook such a benchmarking exercise by developing the *2005 Compendium of States Mercury Activities* (October 2005). The compendium found that 16 states currently have a state mercury action plan in place (see **Chapter 5.4.1**). Several states, including the northeast states and Minnesota, have adopted percent reduction goals for the virtual elimination of anthropogenic mercury sources.[1]

[1] More on the compendium is available at http://www.ecos.org/section/2005_mercury_compendium/.

For Michigan, the largest industrial source of mercury emissions is coal-fired power plants (also known as electric generating units or EGUs). The MDEQ spent a significant amount of time and resources on Michigan's Mercury Electric Utility Workgroup which released its final report on June 20, 2005.[2] Participants of this workgroup consisted of MDEQ and MPSC staff, together with representatives from utilities that potentially could be impacted by the workgroup's recommendations. The charge of the workgroup was to develop a Michigan emissions reduction strategy for coal-fired EGUs that achieve timely and measurable mercury reductions. Included in their report was a comprehensive overview covering fate of mercury in the environment, mercury public health concerns, MDEQ monitoring activities, and control technologies as they relate to coal-fired EGUs. The MSWG has not duplicated these efforts, but instead included this information in this present strategy. Updated information that has become available since the release of the June 2005 *Michigan Mercury Electric Utility Workgroup Final Report* has also been included.

While coal-fired power plants represent the largest air emissions source of mercury, a significant fraction of mercury emissions also come from the use and disposal of mercury-containing products. Additionally, mercury-based amalgam used in some dental fillings is one of the primary sources of mercury in wastewater.

The commitment for further mercury reduction in Michigan is reflected in Governor Granholm's Cabinet Action Plan (now called MIPlan) and the MDEQ's Fiscal Year 2007 Strategic Plan. The development and implementation of this MSWG Strategy has also been incorporated into the MDEQ's strategic plan in order to assure its successful completion. In keeping with the Governor's vision, this strategy will guide the MDEQ to continue its focus on identifying sources of mercury and aggressively implementing action to reduce human and wildlife exposure to mercury. The Governor also sent a letter to Director Chester in April 2006 charging the MDEQ to develop rules to control 90% of the emissions from coal-fired EGUs by 2015. These commitments highlight the importance that Michigan places on mercury reduction efforts in the state.

1.1.1 WHY ELIMINATION?

The MDEQ is not the first environmental agency to implement a mercury elimination approach. Because atmospheric mercury is both of natural origin and re-emitted from past anthropogenic deposition, there is a background level that will always be present in the environment. Therefore, the focus of elimination is the mercury derived from human or anthropogenic sources, not from natural sources. The MSWG's interpretation of elimination will follow that of the U.S. Environmental Protection Agency (EPA) and Environment Canada (this effort is further described in **Chapter 5.4**) with the exception of the word "virtual" which will not be included. The MSWG chose to not include the word "virtual" because in the 21st century, it has acquired an additional meaning (e.g., "not real and only occurring in cyberspace) which could cause confusion. MDEQ's long-term goal is to eliminate anthropogenic mercury use and releases to the environment. The goal of elimination will be sought within the most expedient time frame, through the most appropriate common sense, practical and cost-effective mix of voluntary, regulatory, and incentive-based actions. To assist the MSWG in its elimination approach, the following working definitions were created to address Mercury Use and Mercury Release:

[2] The *Michigan's Mercury Electric Utility Workgroup report* is available in its entirety on the AQD's website at http://www.deq.state.mi.us/documents/deq-aqd-air-aqe-mercury-report.pdf.

MERCURY USE: Mercury or a mercury compound intentionally added to a particular product or device. The definition of a mercury-added product is a product, commodity, chemical, or a product with a component that contains mercury or a mercury compound intentionally added to the product, commodity, chemical, or component in order to provide a specific characteristic, appearance, or quality or to perform a specific function or for any other reason. These products include formulated mercury-added products[3] and fabricated mercury-added products[4]. A mercury-added product or novelty[5] does not include games, toys, or devices merely because they require a button-cell or lithium battery.

MERCURY RELEASE: An anthropogenic release includes, but is not limited to, any human activity resulting in emitting, discharging, spilling, injecting, or disposing of anthropogenic derived mercury into the air, groundwater, surface water or land. The safe long-term storage or sequestration of mercury, its legal disposal in an approved hazardous waste management facility, or any other means of legal disposal is not considered an anthropogenic mercury release provided there is no subsequent release of mercury from these facilities or processes. If the anthropogenic derived mercury is being transferred from one media to another it would still be considered a release, unless it can be permanently sequestered.

In addition to creating these definitions, the MSWG also recognize and acknowledges:

- Once mercury is released into the ecosystem it is not always possible to completely remove it. For example, complete removal may not be practical from open waters, bottom sediments, or landfill leachate that contains mercury. Therefore, the MSWG qualifies elimination of mercury from the ecosystem to concentrations within regulatory parameters that will be protective of public health and the environment. This does not conflict with the long-term goal of eliminating anthropogenic use and releases of mercury.
- Because mercury cycles through the environment and cross-media transfers easily occur, a holistic multi-media approach is needed to adequately assess the success of the overall strategy. This requires a broad risk management view of the relative safety of various options. Relative risk ranking of end points for mercury would depend on various factors including, but not limited to the proximity to a waterbody that supports recreational fishing. For this risk management approach to be effective, humans and wildlife exposure should be avoided. The mercury should be moved to a location with the least risk for release and exposure as well as to prevent any new releases from this area. In reviewing the various releases and end points for mercury, the best and worst cases should be evaluated and ranked based on relative risk. For example, a higher relative risk for mercury is mercury in maternal and fetal blood. A lower relative risk is mercury present in un-mined coal or the earth's crust.

Some reasons why the goal of virtual elimination of mercury have been adopted by the United Nations Environmental Programs (UNEP), the Commission for Environmental Cooperation (CEC) created in connection with the North American Free Trade

[3] Formulated Mercury-Added Product - a chemical product, including but not limited to laboratory chemicals, cleaning products, cosmetics, pharmaceuticals, and coating materials sold as consistent chemical mixture.

[4] Fabricated Mercury-Added Product consists of a combination of individual components that combine to make a single unit, including but not limited to mercury-added measuring devices, lamps, and switches.

[5] Mercury-Added Novelty is a product intended mainly for personal or household enjoyment or adornment and include, but not limited to, items intended for use as practical jokes, figurines, adornments, toys, games, cards, ornaments, yard statues and figures, candles, jewelry, holiday decorations, items of apparel (including footwear), or similar products.

Agreement (NAFTA), the New England Governors/Eastern Canadian Premiers (NEG/ECP), International Joint Commission (IJC), EPA, Environment Canada, the Great Lakes Regional Collaboration (GLRC),[6] and various states include:

- Data have demonstrated that concentrations of mercury in the atmosphere and sediments have increased by a factor of two to five since pre-industrial times because of its liberation from the earth due to anthropogenic activity.
- Mercury can change (primarily by microbial metabolism) in the aquatic environment to MeHg, which bioaccumulates and biomagnifies in the aquatic food chain, resulting in increased mercury exposure for humans and wildlife.
- Human exposure to mercury can result from a variety of pathways including fish consumption (the primary route for the general population) as well as occupational and household uses, etc.
- There is no known biological use or function for mercury in the body.
- Data have demonstrated that a significant fraction of the U.S. population is currently exposed above the safe reference dose.
- Significant local deposition has been demonstrated in the environment.
- Even regions remote from human industrial activity, such as the Arctic, are adversely affected due to transcontinental and global transport of mercury.
- Developing countries continue to use mercury, primarily in the small scale gold mining industry resulting in significant mercury poisonings.

HISTORICAL SUMMARY OF VIRTUAL ELIMINATION

Elimination of persistent toxic substances is not a new idea or recommendation by MDEQ. In North America, virtual elimination was first recommended by the IJC[7] in the Great Lakes Water Quality Agreement (GLWQA) and then followed by other agencies including EPA, Environment Canada and various state agencies (GLWQA, 1987).

Under Annex 12 of the GLWQA persistent toxic substances are described as "any toxic substance with a half-life in water of greater than eight weeks," and states that the intent of the programs specified in this Annex is to "eliminate the input of persistent toxic substances in order to protect human health and to ensure the continued health and productivity of living aquatic resources and human use thereof." The philosophy of the inputs of persistent toxic substances shall be "zero discharge." Zero discharge is very similar to the intent of the U.S. Clean Water Act, (CWA) which sets up the National Pollutant Discharge Elimination System (NPDES) of permits (see **Chapter 3.2**).

The IJC Virtual Elimination Task Force further identified the concept of virtual elimination in their 1993 IJC report titled, "*A Strategy for Virtual Elimination of Persistent Toxic Substances*" (IJC, 1993). This document states that this Virtual Elimination Task Force concurs with the definition of zero discharge and virtual elimination in Annex 12 of the GLWQA which means "no synthesis or production, no release." They also acknowledge that previous laws, regulations and courts have recognized the reality that application of the "zero discharge" philosophy cannot necessarily mean achievement of absolute zero. The Virtual Elimination Task Force believes this necessary interpretation should not impede progress towards the virtual elimination goal and they offer some of the following conclusions pertinent to mercury:

- Virtual elimination is an overall strategy that requires different approaches – some preventative, some remedial – to control or eliminate different inputs and *in situ* contamination.

[6] The 12/12/05 *Great Lakes Regional Collaboration Strategy* is available at http://www.glrc.us/strategy.html.
[7] The IJC was established through the 1909 Boundary Waters Treaty between the U.S. and Canada.

- The virtual elimination strategy must apply to new potentially persistent toxic substances that may be created, as well as existing persistent toxic substances.
- The virtual elimination strategy also must apply to persistent toxic substances already present in the Great Lakes Basin Ecosystem. Once persistent toxic substances have been released into the ecosystem it is not always possible to completely remove them, for example, complete removal may not be practical from open waters, bottom sediments, or landfill leachate that contain mercury. Therefore, the qualifier "virtual" is appropriate as applied to eliminating the presence of persistent toxic substances from the ecosystem to concentrations that will be protective of public health and the environment.
- The virtual elimination strategy must prevent the deliberate input of any additional quantities of persistent toxic substances to the ecosystem. Given our technological capability to measure lower and lower concentrations of contaminants in the ecosystem, virtual elimination of existing persistent toxic substances may never reach zero. Rather, the strategy challenges us to continuously strive to reduce the amount entering the environment, en route to fulfilling the Agreement's virtual elimination obligation.
- Because some persistent toxic substances already are present in the ecosystem, and because life in the Great Lakes Basin Ecosystem is vulnerable to contamination from persistent toxic substances, implementation of the virtual elimination strategy requires that the policy of zero discharge be applied to prevent further releases from all sources of persistent toxic substances.

The MSWG endorses these conclusions from the IJC (with the exception of the word "virtual") and will use them as guiding principles for implementing the strategy. Several other agencies have also followed this approach including EPA and Environment Canada in their Bi-National Toxics Strategy and the Lake Superior Bi-National Program, the GLRC, the NEG/ECP, the CEC under the NAFTA, and the UNEP (see **Chapter 5.4**).

1.2 INTRODUCTION

Mercury, a naturally occurring element found in air, water and soil, is a persistent bioaccumulative toxic (PBT) pollutant that has been targeted for source identification, reduction, and elimination through various state, federal, and international efforts. Over the past several decades, MDEQ (formerly part of the Michigan Department of Natural Resources [MDNR]) has implemented a variety of activities that include source identification, monitoring, regulations and policies for identifying, preventing or eliminating the use and release of this toxic pollutant. Primary methods for accomplishing these efforts include:

- controls through permits and enforcement;
- legislation prohibiting the sale or use of certain mercury products;
- research and monitoring of mercury emissions and deposition data; and
- aggressive efforts to encourage voluntary reductions in the use of mercury-containing products and devices [through pollution prevention (P2)] along with education and outreach activities.

Significant efforts have been put forth, but there has yet to be a comprehensive multi-media approach to guide efforts in phasing out the use and preventing the release of this persistent pollutant. The MSWG Strategy has been developed by staff representing air, water, waste, and remediation programs. It is the expectation of the MSWG that this document will bridge the gap between policy and the critical changes needed to fulfill Michigan's goal of eliminating

anthropogenic mercury use and releases in order to eliminate the need for fish consumption advisories due to mercury contamination, as well as eliminating the need to list waterbodies as "impaired" under the CWA's 303d list. This overall goal of elimination is for the protection of Michigan's citizens and wildlife that consume fish and for individuals that may come into contact with mercury spills, as well as to avoid impacting neighboring states and Canada from mercury transport and deposition.

The MSWG began their deliberations in January of 2006 by developing a charter which includes purpose, goals, and action steps (or recommendations) for the MDEQ. Ensuing Director Chester's charge, the MSWG determined that their purpose was to develop a comprehensive strategy by identifying current sources, monitoring activities, implementing policies and regulations, and making specific recommendations toward the goal of eliminating anthropogenic mercury use and releases in Michigan within a specified time frame. The specific goals developed by the MSWG are (further discussed in **Chapter 9**):

- **GOAL 1 – Baseline Development:** Identify all anthropogenic mercury use and releases in Michigan; develop a defined baseline to measure mercury releases to all media including air, water, and land; and utilize this baseline to measure reduction progress.
- **GOAL 2 - Elimination/Reduction Activities:** Eliminate anthropogenic mercury use and releases to the environment in Michigan through various approaches in order to meet designated water uses in the state, including fish consumption.
- **GOAL 3 – Measuring Success:** Create a mechanism to measure progress toward the goal of eliminating anthropogenic mercury use and releases to the environment in Michigan, using defined baseline data.

The MSWG developed two interim goals that would assist in tracking progress towards the final goal of elimination. The following interim goals were developed after reviewing current reduction activities and recommended reductions from specific sectors in Michigan as well as the NEG/ECP and Lake Superior Bi-National Strategy (further information is available in **Chapters 5.4.2** and **5.4.3**, respectively):

- Reduce anthropogenic mercury use and releases in the state by 50% by 2010;
- Reduce anthropogenic mercury use and releases in the state by 90% by 2015.

In order to evaluate the success of achieving the mercury use and release reductions, a baseline must be established in order to measure progress. The details of this baseline will be developed as part of the MSWG's implementation plan. Because there has been a significant reduction in certain sectors such as hospital medical infectious waste incinerators and municipal waste combustors as well as a reduction in product usage, it will be difficult to obtain additional reductions if a fairly recent baseline is used. Therefore, a baseline may be used that is similar to that set by the EPA Bi-National Strategy of 1990 to continue to work on achieving 90% reduction (which is beyond the current Bi-National Strategy goals). For coal-fired EGUs, the baseline of 90% reduction by 2015 will mirror the baseline that will be a part of the regulations being developed for this sector as directed by Governor Granholm in her letter to MDEQ Director Chester (see **Appendix E**).

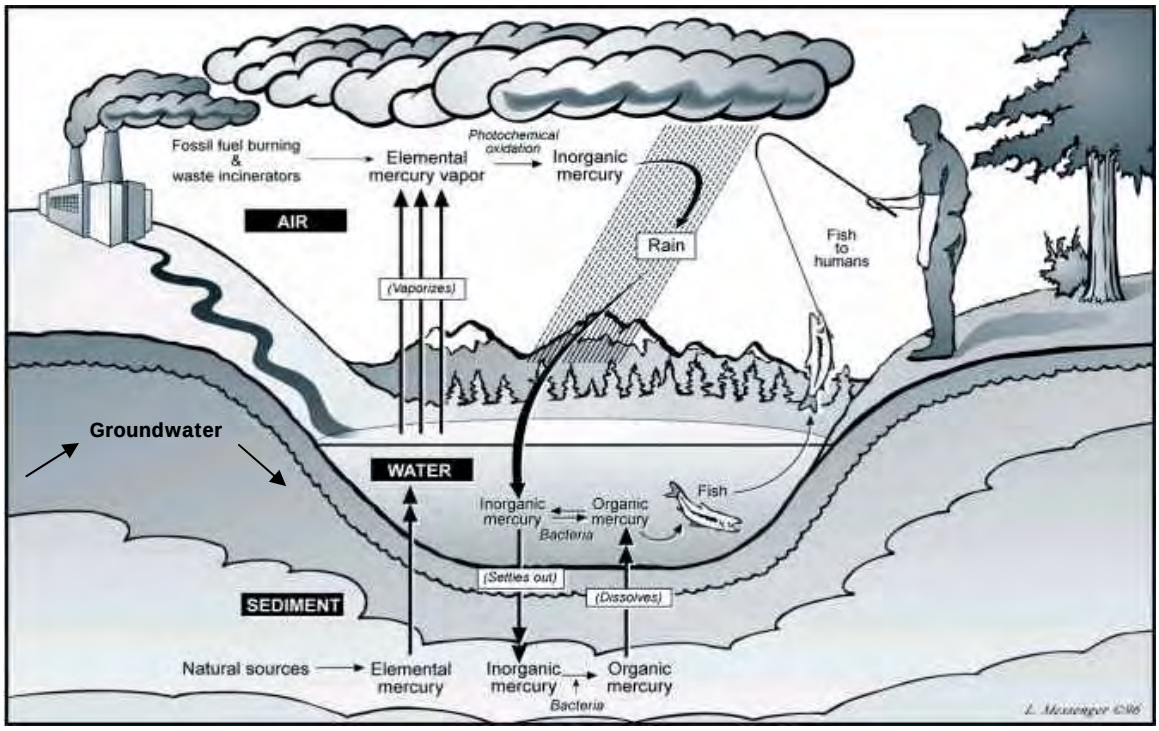
The Goal 2 Elimination/Reduction Activities were broken down into the following four separate categories with each category containing its own action steps: Regulatory Approaches, Collaboration/Partnerships, Education/Outreach, and Monitoring/Research and are listed in more detail in **Chapter 9**. These elimination/reduction activities will be the primary tasks for determining success in meeting MDEQ's long-term goal.

1.3 OVERVIEW OF THE PROBLEM

Mercury (or Hg) is a neurotoxicant that affects brain function and can adversely affect development in children. Mercury exists in several forms: elemental mercury [Hg(0)] or metallic mercury, inorganic mercury compounds (such as mercuric chloride), and organic mercury compounds (such as MeHg). Hg(0), a shiny, silver-white metal that is liquid at room temperature, is used in thermometers, fluorescent light bulbs, and some electrical switches. When dropped, Hg(0) breaks into smaller droplets which can go through small cracks in materials or become strongly attached to certain substances. At room temperature Hg(0) can evaporate to become an invisible, odorless toxic vapor. Inorganic mercury compounds that take the form of mercury salts, are generally white powder or crystals (with the exception of mercuric sulfide or "cinnabar" which is red), and have been included in products such as fungicides, antiseptics, or disinfectants. Some skin lightening and freckle creams, as well as some traditional medicines, can also contain mercury compounds. Organic mercury compounds have historically been used in pesticides and paints. Organic mercury compounds can also be formed when microscopic organisms convert inorganic mercury into MeHg, the compound of highest concern for human and wildlife exposure.

Mercury and its compounds can adversely impact health by several routes of exposure. Hg(0) is primarily toxic through the inhalation route, whereas mercury salts and MeHg are toxic through ingestion. Hg(0) exposure can occur through improper handling of broken devices that contain Hg(0) such as thermostats or thermometers or from occupational exposure from the manufacturing of Hg(0)-containing equipment such as mercury relays and switches. However, the primary route of exposure for the general public is through the consumption of fish that contains MeHg in fish tissue (see **Figure 1-1**).

FIGURE 1-1: MERCURY CYCLE



Different species and sizes of fish will contain a range of MeHg. In 1970, Michigan became the first state in the nation to issue fish consumption advisories due to significant amounts of mercury discharged from chlor-alkali plants. Because of continued discovery of fish contaminated with mercury, there has been, since 1988, a statewide fish consumption

advisory and there is also a federal fish consumption advisory in place due to mercury concentrations in various fish species. For Michigan, the mercury fish consumption advisory is a multi-department effort. The MDNR collects the fish samples and the MDEQ provides the edible fish tissue (i.e. fillet) to MDCH analytical laboratory, where the individual samples are homogenized and analyzed (further discussed in **Chapter 6.2.5**). The MDEQ and MDCH collaborate to evaluate the mercury fish tissue results relative to two mercury fish tissue criteria, 0.5 milligrams per kilograms [mg/kg] and 1.5 mg/kg. The MDCH uses the two trigger levels to issue "restrict consumption" and "no consumption" mercury advisories in their fish consumption guide. A "restrict consumption" advisory, for those species with sample concentrations between 0.5 mg/kg and 1.5 mg/kg, is defined as no more than one meal per week for the general population and no more than one meal per month for nursing mothers, pregnant women, women who intend to have children, and children under the age of 15. A "no consumption" advisory is for waters and species with sample concentrations over 1.5 mg/kg. Between 1985 and 2003, approximately 69% of the 279 lakes sampled by MDEQ had at least one fish at or exceeding the 0.5 mg/kg advisory limit and 10% of the lakes had at least one sample at or exceeding the 1.5 mg/kg limit.

The MDCH's "*2007 Michigan Family Fish Consumption Guide*," provides consumption advice by waterbody, fish species, and fish length. The waterbodies are grouped by the four Great Lakes Watersheds which then list the bays on the Great Lake (that have additional advisories) followed by the lakes, rivers, reservoirs, or impoundments. The 2007 guide, updated in April 2007, lists all of Michigan's inland lakes, reservoirs, and impoundments as having a Statewide Mercury Advisory. This statewide advisory is a special "restrict consumption" advisory stating that no one should eat more than one meal a week of the following kinds and sizes of fish (shown respectively):

- rock bass, perch, or crappie over 9 inches in length
- any size largemouth or smallmouth bass

- any size walleye, northern pike, or muskellunge.[8]

The Statewide Mercury Advisory does not apply to the Great Lakes or rivers in Michigan. **Table 1-1** provides the species and waterbodies for the Great Lakes, bays, rivers, and connecting channels that also have a "restrict consumption" advisory. Also included are those inland lakes that have additional species of fish listed in the "restrict consumption" advisory.[9]

[8] MDCH's consumption info is at http://www.michigan.gov/mdch/0,1607,7-132-2945_5105-13110--,00.html.
[9] The 2007 Michigan Family Fish Consumption Guide is at http://www.michigan.gov/documents/FishAdvisory03_67354_7.pdf.

TABLE 1-1: RESTRICT CONSUMPTION MERCURY ADVISORIES FOR THE GREAT LAKES, RIVERS, AND OTHER AREAS WITHIN THE GREAT LAKES WATERSHEDS

GREAT LAKES	WATERBODY	SPECIES (SIZE)
LAKE ERIE	Does not list mercury as a fish contaminant	
Lake Erie Watershed	Detroit River	Freshwater Drum (18" or larger)
	Hudson Lake	Carp (26" or larger)
	Lake St. Clair*	Brown Bullhead (14-18") Carpsucker (18" or larger) Large/Smallmouth bass (14" or larger) Pike (26" or larger) Walleye (22" or larger) White Bass (12" or larger) White Perch (10-14")
	Pontiac Lake	Channel Catfish (22" or larger)
	St. Clair River*	Carp (22-30") Freshwater Drum (14" or larger) Gizzard Shad (10-22")
	Stony Creek Impoundment	Northern Pike (22" or larger)
LAKE HURON	Does not list mercury as a fish contaminant	
Lake Huron Watershed	Au Sable River (at Oscoda)	Walleye (26" or larger)
	Au Sable River (Middle Branch)	Walleye (14" or larger)
	Cass River*	Northern Pike (26" or larger) Sucker (22" or larger)
	Kearsley Reservoir	Largemouth Bass (18" or larger)
	Saginaw Bay	Walleye (22" or larger)
	St. Mary's River	Northern Pike and Walleye (22" or larger)
	Sanford Lake	Channel Catfish (26" or larger)
	Stevenson Lake	Bullhead (12" or larger)
LAKE MICHIGAN	All of Lake Michigan	Walleye (22" or larger)
Lake Michigan Watershed	Elk Lake	Lake Trout (26" or larger)
	Fawn River	Smallmouth Bass (14-30")
	Glen Lake*	Lake Trout (22-30")
	Green Bay* (includes Cedar and Menominee Rivers)	Smallmouth Bass and Walleye (18" or larger)
	Green Lake	Lake Trout (14" or larger)
	Greenwood Reservoir* (Escanaba River)	Northern Pike (22-30")
	Little Bay de Noc	Smallmouth Bass (18" or larger)
	Manistique River (upstream and downstream)	Northern Pike and Walleye (22" or larger)
	Menominee River	Carp (6" or larger) Sturgeon (30" or larger) Suckers (14" or larger) Walleye (18" or larger)
	Michigamme River System (including Lake Michigamme, Michigamme Reservoir, Peavy Pond, and Pain River Pond)	Burbot and Northern Pike (22" or larger) Suckers (18" or larger) Walleye (14" or larger)
	Muskegon River	Suckers (18" or larger)
	North Lake Leelanau	Lake Trout (14" or larger)
	Net River	Northern Pike (22" or larger) Walleye (14" or larger)
	Pere Marquette River	Brown Trout (14" or larger)
	Pigeon River	Smallmouth Bass (18" or larger)
	Rabbitt River (upstream and downstream	Suckers (18" or larger) Largemouth Bass (14" or larger) Northern Pike (22" or larger)
	Selkirk Lake	Yellow Bullhead (10-18")
	St. Joseph River (including Chapin Lake)	Largemouth Bass (18" or larger)
	Torch Lake*	Lake Trout (22-26")
LAKE SUPERIOR	All of Lake Superior	Lake Trout (30" or larger)
Lake Superior Watershed	Carp River*	Northern Pike (22" or larger)
	Carp Creek*	Brook Trout (10" or larger)

*See **Table 1-2** for "No Consumption Advisory" information.

Basically, larger predator fish, especially large walleye, northern pike, muskellunge, bass, and lake trout usually have higher concentrations of mercury and other chemicals than the smaller fish. **Table 1-2** lists those inland lakes and streams, along with the species and size of fish that MDCH has listed under their 2007 "no consumption" guidelines.

TABLE 1-2: NO CONSUMPTION MERCURY ADVISORIES FOR MICHIGAN WATERS

GREAT LAKES WATERSHED	WATERBODY	SPECIES	LENGTH (IN INCHES)
Lake Erie	Lake St. Clair	Muskellunge	30+
	St. Clair River	Carp	30+ (26+*)
		Gizzard Chad*	10-22
Lake Huron	Cass River (below Bridgeport)	Channel Catfish	14+
Lake Michigan	Craig Lake	Northern Pike	30+
	Glen Lake	Lake Trout	30+
	Green Bay	Walleye*	26+
	Greenwood Reservoir	Northern Pike	30+
	Higgins Lake	Lake Trout	30+
	Round Lake	Northern Pike	22+
	Torch Lake	Lake Trout	26+
	Unnamed Lake (Baraga Co., T49N, R31W, S35)	Northern Pike and Walleye	22+
		Yellow Perch	10-18
	West Branch Lakes, Southeast and Southwest (Alger Co., T48N, R14W, S31)	Northern Pike	22+
		Walleye	22-30
		Yellow Perch	10-18
Lake Superior	Carp River (downstream of Deer Lake)	All Species except Brook Trout, Northern Pike, and Suckers	6+
	Carp Creek (upstream of Deer Lake)	All Species except Brook Trout	6+
	Chaney Lake	Northern Pike	26+
	Deer Lake (Alger County)	Northern Pike	26+
	Deer Lake (Marquette County)	All Species	6+
	Lake Le Vasseur	Northern Pike	26+
	Lake Superior	Lake Trout*	30+
	Langford Lake	Walleye	22+

*This "no consumption advisory" fish species size limit is for women and children only.

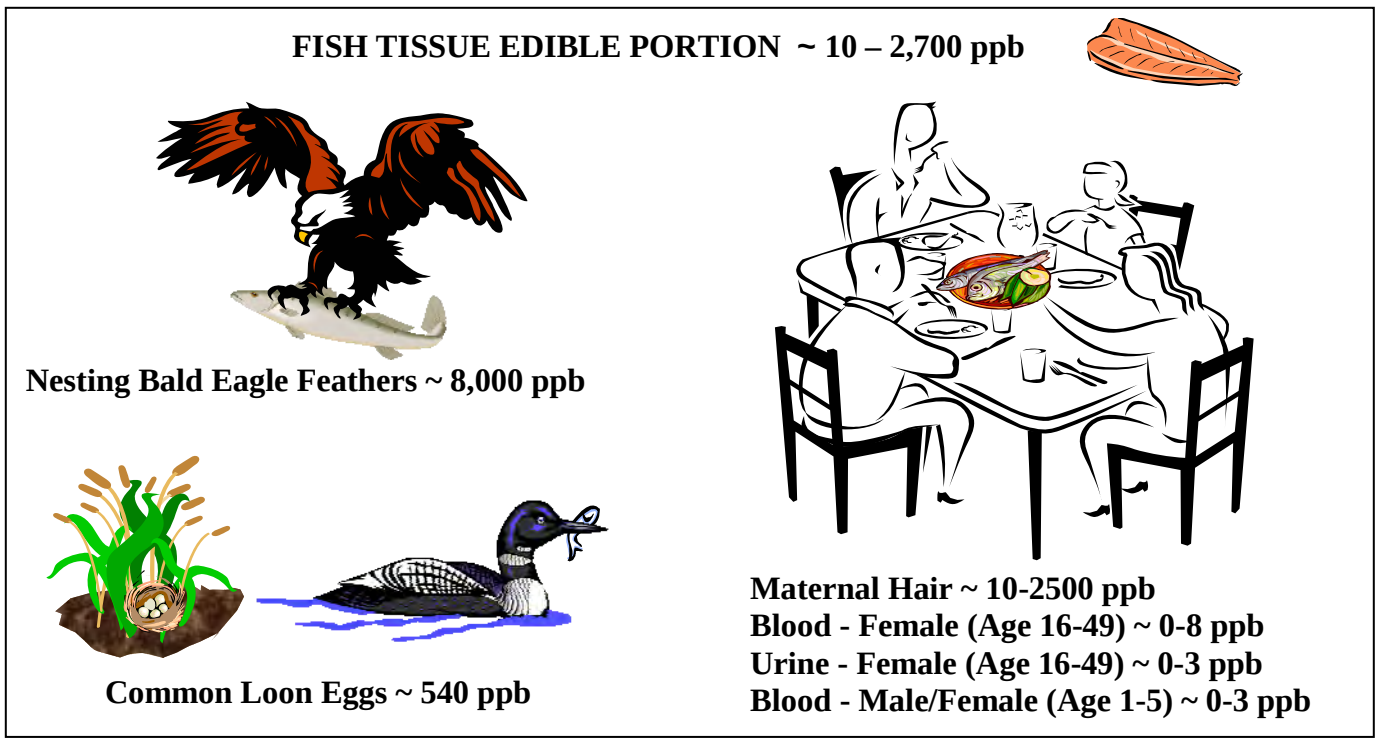
It is important to note that eating fish is healthy for families. Fish are a great source of protein, vitamins, and minerals, are low in saturated fat, and can help prevent heart disease in adults. In addition, the omega-3 fatty acids found in fish are good for brain function in unborn and breast-fed babies and children. Due to this, the MDCH has recently released two new brochures, "*A Family Guide to Eating Fish*" and the "*Avoid Mercury In Fish And Seafood Shopping & Restaurant Guide*" about how to select fish species at the grocery store or restaurant that are low in mercury content.[10]

[10] These brochures are available at http://www.michigan.gov/documents/family_fish_166020_7.pdf and http://www.michigan.gov/documents/avoid_mercury__166019_7.pdf, respectively.

The MDCH also provides a guide about harvesting fish and wild game that are safe to eat without concern for chemical pollution in the Saginaw Bay Watershed (22 counties). The "*Guide to Safe Fish and Wild Game Consumption in the Saginaw Bay Watershed*" includes a list of waterbodies that have fish that are safe to eat on a regular basis, a list of waterbodies that have had adequate testing and do not have fish advisories, a wild game consumption advisory for the Tittabawassee River flood plain, and a list of all the waters within the Saginaw Bay Watershed that are in the *Michigan Family Fish Consumption Guide*.[11] The Saginaw Bay Watershed includes the following counties: Arenac, Bay, Clare, Genesee, Gladwin, Gratiot, Huron, Iosco, Isabella, Lapeer, Livingston, Mecosta, Midland, Montcalm, Oakland, Ogemaw, Osceola, Roscommon, Saginaw, Sanilac, Shiawassee, and Tuscola.

Various studies have been performed to investigate mercury concentrations in Michigan's humans and wildlife. Because MeHg is a PBT, the release of the pollutant biomagnifies in the food chain and builds up to levels that can be unsafe to humans and wildlife. **Figure 1-2** shows the Michigan concentrations (listed as parts per billion [ppb]) and **Table 1-3** provides the reference information.

FIGURE 1-2: MERCURY CONCENTRATIONS IN MICHIGAN'S HUMANS AND WILDLIFE



[11] This guide is available at http://www.michigan.gov/documents/fishing_guide_166021_7.pdf.

TABLE 1-3: MERCURY CONCENTRATIONS IN MICHIGAN'S HUMANS AND WILDLIFE

SOURCE	MEAN CONCENTRATION (OR RANGE)	SOURCE REFERENCE	BENCHMARK OR REFERENCE LEVEL	BENCHMARK REFERENCE
Fish Tissue Edible Portion	0.01 to 2.7 ppm (10 to 2,700 ppb)	MDEQ Fish Contamination Database, 2004	a) 0.35 ppm b) 0.5 ppm	a) MDEQ Water Bureau fish tissue criterion for assessing attainment of WQS. b) MDCH trigger level for restrict consumption advisory.
Maternal Hair (Michigan Cohort)	Up to 2.50 µg/g (ppm) (range = 0.01 to 2.5 ppm)	POUCH*, Xue et al., 2006	RfD corresponds to ~1 ppm in hair	EPA IRIS RfD for MeHg is 0.1 µg/kg/day**
Blood - Female Age 16-49	1.9 µg/L (ppb) (0.66 to 8.0 µg/L) (50th - 95th percentile)	***MDCH Public Health Code (7-13% > RfD)	RfD corresponds to ~5.8 µg/L in maternal blood (3.5 µg/L in maternal blood if cord blood ratio is ~ 2:1)	EPA IRIS RfD for MeHg is 0.1 µg/kg/day**
	National Information 1.02 µg/L (ppb) (0.9 to 7.10 µg/L) (50th - 95th percentile)	99-00 NHANES		
Urine - Female Age 16-49	1.1 µg/L (ppb) (0.009 to 2.83 µg/L)	***MDCH Public Health Code (4% > World Health Organization level)	a) 4-5 µg/L b) 35 µg/g of creatinine	a) average general population levels (World Health Organization, 1990) b) occupation biological exposure index (American Council of Governmental Industrial Hygienists, 2006)
	National Information 0.719 µg/L (ppb) (0.76 to 5.0 µg/L) (50th - 95th percentile)	99-00 NHANES		
Blood - Male/Female Age 1-5 yrs	0.5 µg/L (ppb) (0.009 to 3.0 µg/L) (50th - 95th percentile)	***MDCH Public Health Code	RfD corresponds to ~5.8 µg/L in blood	EPA IRIS RfD for MeHg is 0.1 µg/kg/day**
	National Information 0.343 µg/L (ppb) (0.3 to 2.3 µg/L) (50th - 95th percentile)	99-00 NHANES		
Nestling Bald Eagle Feathers (1999-2000)	8 µg/g (ppm) (3.15 to 41.86 ppm)	Roe et al., 2001	N/A	Roe (2001) concluded that Hg is not affecting bald eagle productivity in the Great Lakes region.
Common Loon Eggs (1997-2001)	0.54 µg/g (ppm) (0.18 to 1.45 µg/g) or (180 to 1,450 ppb)	Evers et al., 2003	Consumption of 0.16 µg/g Hg in whole fish	Hg level in whole fish observed to pose adverse reproductive effects to loons.

*POUCH is a prospective study of biologic and psychosocial factors related to preterm delivery. Maternal hair mercury levels were assessed at mid-term in over 1,000 pregnant women recruited from 52 prenatal clinics in five Michigan communities.

**Note: Care should be taken when comparing maternal hair and blood concentrations with the RfD concentration since the former represent total Hg concentration while the latter refers only to MeHg. Data from the 1999-2000 NHANES estimated that women 16- to 49 years of age ingested a geometric mean of 1.22 µg of Hg per day from fish/seafood (approximately 85% as MeHg) (Mahaffey, 2004). In contrast, urinary excretion of Hg is largely in the inorganic form.

***Note: This Michigan data does not necessarily represent exposure to the general public. The data may include individuals exposed to occupational levels and this data set may not be entirely complete as it was the first year of reporting under this new MDCH public health code R 325.61 to R 325.68 as added to the Michigan Administrative Code.

Acronyms: ppb = parts per billion; ppm = parts per million; µg/g = microgram per gram; µg/kg/day = micrograms per kilogram per day; µg/L = microgram per Liter; EPA = Environmental Protection Agency; IRIS = Integrated Risk Information System; MDCH = Michigan Department of Community Health; MDEQ = Michigan Department of Environmental Quality; MDNR = Michigan Department of Natural Resources; NHANES = National Health and Nutrition Examination Survey; POUCH = Pregnancy Outcomes and Community Health Study; RfD =oral reference dose; WQS = water quality standards

1.3.1 HUMAN EXPOSURE TO METHYLMERCURY (MEHG)

MeHg is actively transferred to the fetus across the placenta by amino acid carriers (Sakamoto et al., 2001). A recent study of over 1,000 pregnant women in Michigan found that those with relatively high levels of mercury in their hair are three times more likely to give birth prematurely. Mercury levels were related to fish consumption, and the greatest source of mercury exposure in the population studied appeared to be canned fish (Xue et al., 2006). New data have also demonstrated that cord blood mercury is consistently higher than maternal blood mercury; on average 70% higher, or approximately 2:1 (Morrisette et al., 2004; Stern and Smith, 2003; and Butler et al., 2006). If the cord blood to maternal blood ratio is assumed to be 2:1 (based on the reported range of variability between 0.8 to 4.36 microgram per Liter [µg/L]), then fetal exposures above the EPA's oral reference dose (RfD) of 0.1 microgram per kilogram per day (µg/kg/day) are associated with maternal blood levels of total mercury at or above 3.5 µg/L (5.8 µg/L is the concentration in maternal blood assuming a 1:1 cord blood to maternal blood ratio) (Mahaffey, 2004). The EPA RfD definition is (EPA, 2001a):

> "The RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) over a lifetime (70 years) that is likely to be without an appreciable risk of deleterious effects."

Utilizing this more realistic ratio of maternal blood to fetal cord blood ratio, it would mean that over 600,000 infants born annually in the U.S. are exposed to levels of MeHg above the EPA RfD (based on 15.7% of adult women age 16 to 49 with blood levels at or greater than 3.5 µg/L who participated in the National Health and Nutrition Examination Survey [NHANES] from 1999 and 2000) (Mahaffey, 2004; CDC, 2004). There were over 10% of woman age 16-49 years (who participated in NHANES from 1999 to 2002) that had blood mercury concentrations at or greater than 3.5 µg/L (which equals to an estimated 410,000 infants born annually exposed to MeHg above the EPA RfD) (Mahaffey, 2005).[12] It should also be noted that children in the age group of three to six years have higher intakes of MeHg than do adults relative to body weight. Approximately 25% of children exceed the RfD, and 5% of children have MeHg exposure from fish/shellfish two to three times the RfD (i.e., 0.29 µg/kg body weight/day) (EPA, 1997c). A New Jersey exposure assessment estimates that 20% of women of reproductive age exceed the RfD, suggesting that coastal populations may be more at risk than the national average suggests (Stern et al., 1996; cited in Stein et al., 2002).

Subsistence populations that rely on a greater amount of fish in their diet, such as Native American Indians, may have elevated MeHg concentrations compared to the general populations. **Figure 1-3** shows the Native American Indian populations in Michigan.

[12] Kate Mahaffey, EPA, presented the *Update on Mercury Issues and the NHANES Study (Regional Comparisons)* at the 2005 National Forum on Contaminants in Fish held September 18-21, 2005, in Baltimore MD (available at http://www.epa.gov/waterscience/fish/forum/2005/presentations/).

FIGURE 1-3: MICHIGAN TRIBAL POPULATIONS

There have been elevated levels of MeHg exposure throughout the world from eating fish (Pirrone and Mahaffey, 2005). Some farm raised fish can also have elevated levels of MeHg if these fish are fed fish meal containing MeHg (Choi and Cech, 1998). People can also be exposed to MeHg from eating marine fish, including sword fish and tuna. Studies have documented that consuming marine fish in the U.S. has resulted in elevated blood mercury concentrations (Hightower and Moore, 2003).

While current mercury exposures throughout the world are known to be lower than that of the historical epidemic poisonings in Minamata, Japan, and Iraq (Harada, 1978; EPA, 2001b), evidence does exist that for many populations, exposures are above the RfD and constitute an important health risk. The two current major longitudinal studies, the Faroes Islands and the Seychelles have looked at MeHg exposure to children for over a decade, beginning with *in utero* exposure. The Faroes Island studies have consistently shown neurobehavioral deficits associated with exposure (Grandjean, 1997). Initially, no adverse effects were seen in the Seychelles; however, recent reports on children showing decreases in fine motor function, suggest that the effects may develop as the child matures (Van Wijngaarden et al., 2006). Recent data in the literature now suggests that there may be a link between MeHg exposure and myocardial infarction (Virtanen et al., 2005; Yoshizawa et al., 2002).

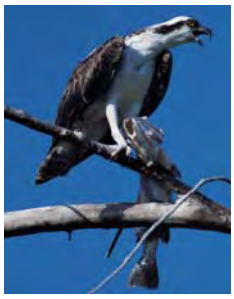
Many argue that the benefits of eating fish far outweigh any risks from exposure to MeHg, because fish is a good source of protein and it contains omega-3 fatty acids that are good for heart health and brain function. However, like MeHg variability in fish the range of omega-3 fatty acids also vary depending on the species of fish. Some fish that are higher in MeHg may also be lower in omega-3 fatty acids, therefore decreasing any benefit one may get from the omega-3 fatty acids. Fresh water fish tend to have lower levels of omega-3 fatty acids compared to ocean fish (Mahaffey, 2004). This information demonstrates that in some cases, the benefit of eating fish may not necessarily outweigh the risk of eating fish for certain populations.

1.3.2 WILDLIFE IMPACTS FROM MEHG EXPOSURE

MeHg accumulation in the food chain can affect both people and wildlife that are exposed by eating mercury-contaminated fish. While extreme MeHg exposure can be deadly, lower level chronic exposures through fish consumption can still cause harm, in particular on the nervous and reproductive systems. Existing EPA water quality criteria indicates that wildlife are more sensitive than humans to MeHg exposure (EPA, 1995a). Fish-eating birds and mammals are more highly exposed to mercury than any other known component of aquatic ecosystems (see examples in **Figure 1-4**). Adverse effects of mercury on fish, birds, and mammals may include death, impaired growth and development, reduced reproductive success, and behavioral abnormalities (Wolfe et al., 1998).

FIGURE 1-4: MICHIGAN WILDLIFE EXPOSED TO MEHG

Predatory animals primarily associated with aquatic food chains accumulate more MeHg than those associated with terrestrial food chains. In Michigan, the common loon, mink and otter have been poisoned by MeHg as a result of ingestion of mercury-contaminated fish (per MDNR website).[13] In a study of furbearing mammals in Wisconsin, the species with the highest tissue levels of mercury were otter and mink, which are top mammalian predators on the aquatic food chains (Sheffy and St. Amant, 1982). A study of a small Michigan Upper Peninsula (U.P.) lake found that mercury levels in smallmouth bass were above a hazard index for mink, and were within a factor of two of the hazard index for bald eagles (Henry et al., 1998). Top avian predators of aquatic-based food chains include raptors, such as the osprey (shown at right) and the bald eagle.



Other fish eating birds at risk include common loons. Loons are particularly vulnerable to environmental poisoning as they are long-lived (up to 30 years) and they spend their lives in the water, feeding mostly on fish. A recent study involved sampling from eight states in North America. These results reported that up to 30% of the loon eggs sampled at several Michigan sites contained "moderate risk" levels to the development of the chicks (Evers et al., 2003). Smaller birds feeding at lower levels in aquatic food chains also may be exposed to substantial amounts of mercury due to their high food consumption rate per body weight, relative to larger birds (Rimmer et al., 2005).

Research in the Northeast U.S. has demonstrated that elevated levels of mercury in yellow perch and in the blood and eggs of the common loon have been linked to elevated atmospheric mercury deposition, have high landscape sensitivity, and/or experience large reservoir fluctuations (Evers et al., 2007).

In addition to effects on wildlife, mercury may cause effects directly on some fish. For example, recent laboratory studies reported that MeHg decreased the reproductive success of fathead minnows, (Hammerschmidt et al., 2002; Drevnick and Sandheinrich, 2003).

1.3.3 HUMAN EXPOSURE TO ELEMENTAL MERCURY [HG(0)]

While the general public is primarily exposed to mercury in the form of MeHg through the consumption of fish, exposure to Hg(0) can also occur. Significant exposure to Hg(0) usually happens indoors in a residential, school, or commercial setting such as a medical office. The home is the most common spill event location and usually involves a relatively small amount of Hg(0), for example, the 0.5 to 1.5 g (grams) of Hg(0) contained in a common fever thermometer. The MDCH and local health departments respond to numerous calls each year due to mercury spills in the home (see **Chapter 2.6** for all Hg(0) reported spills). The national Poison Control Center database for the years 2000 and 2001 averaged approximately 18,000 thermometer break reports per year. This number is considered to be a tiny fraction of the total spill incidences as the majority of spills go unreported. Hg(0) spills in industrial settings are a separate consideration since they are regulated and have air monitoring and worker biological monitoring to detect hazardous situations. Manufacturers that produce mercury-containing items have had incidents of employees exceeding the U.S. Occupational Safety and Health Administration (OSHA) blood safe mercury levels in Michigan.

[13] Information is available under Wildlife and Habitat at http://www.michigan.gov/dnr.

The routes of exposure for Hg(0) can be dermal contact, ingestion, or inhalation of the vapors that are emitted from uncontained Hg(0). Of the three routes, inhalation can result in the greatest toxicity as the human body absorbs about 80% of inhaled mercury. Some will be excreted very slowly while the rest will accumulate, and combined with mercury from other sources (such as fish ingestion) may produce and/or contribute to symptoms and adverse health effects.

Mercury will vaporize more rapidly when heated, resulting in high air concentrations in enclosed spaces. In a home, if a thermometer breaks on a stove or in the ducts of a furnace, it can result in an acute exposure that may produce chest tightness, fever, weakness, stomach upset, gingivitis, and eventually kidney failure, neuropathy, and death. Neurological symptoms can include tremors, lack of coordination of movement, short-term memory loss, and motor skill impairment. Some of the health effects may be permanent even after the exposure has been mitigated and treatment, if necessary, has been administered.

Chronic exposure to mercury at lower air concentrations can result in many health effects some of which are personality changes, decreased vision and hearing, peripheral nerve damage, hypertension, and kidney damage. In any mercury exposure event, it is most likely the youngest children present who will be the first and the most severely impacted. The pediatric hypersensitivity most commonly documented is a condition called acrodynia or "Pinks Disease." It can result from inhalation of mercury vapor and other routes of mercury exposure. It is characterized by red palms and soles of the feet, skin peeling, hair loss, increase heart rate and blood pressure, behavioral changes, muscle weakness and sensitivity to light. The following are case studies of children exposed to mercury vapors:

- A recent case involved the misdiagnosis of a 4-year old Pakistani male presented with three months of irritability, generalized pruritic rash, pink and peeling palms and soles, hiperhidrosis and hypertension. He was discharged with a diagnosis of hypertension. However, due to his persistent symptoms, a heavy metal screening was done that showed a 24-hour urine mercury level of 9 µg/L and serum mercury level of 8 µg/L. Two months later the 24-hour urine mercury level increased to 49 µg/L and the serum mercury level was 24 µg/L. Inspection of the house revealed breathing space mercury levels of 14,000-19,000 nanograms per cubic meter (ng/m^3) with a metal trash can measuring 40,000 ng/m^3. His mother later recalled discarding a malfunctioning thermometer. After chelation therapy and removal from the home, he began showing improvement (Smolinske, 2007).
- A 1995 case report from Iowa describes a 10-year old boy who played with Hg(0) and spilled it on a bedroom carpet, which was vacuumed repeatedly afterwards. One month later the boy developed immune thrombocytopenic purpura (a disorder where the blood does not clot normally), rash, renal and respiratory failure, fever, irritability, and peripheral neuropathy. One month later his 17 and 12-year old siblings had similar health problems. The urine mercury level of the 12-year old was 306 µg/L. The child confessed to bringing home 1 lb of Hg(0) from school. Air testing of the home found mercury levels as high as 140,000 ng/m^3 of air. Acceptable air levels for a residential structure after a thorough mercury spill clean-up is 1,000 ng/m^3. The children responded well to chelation therapy. Their parents and a 15-year old sibling in the home had high biological test levels as well but exhibited no symptoms (Fuortes et al., 1995).

- Three children from Grand Rapids, Michigan were hospitalized with mercury poisoning in 1989 when it was discovered that one of the children could no longer walk. Investigation revealed that exposure had occurred two to three months prior after a small vial of mercury was spilled in the children's bedroom (Department of Health and Human Services, 1991).
- In a case study that occurred in 1989, a four year old boy was diagnosed with acrodynia from the inhalation of mercury vapors released during the application of latex paint. In October 1989, the Michigan Department of Agriculture (MDA) prohibited further sales of the inappropriately formulated paint that contained phenylmercuric acetate beyond the allowed EPA limit (Department of Health and Human Services, 1990). In 1990, responding to pressure of an EPA mandatory cancellation of mercury in latex paints, the paint manufacturing companies responded with a "voluntary" cancellation of all product registrations nationally for mercury in interior latex paints. In 1992, the cancellation was extended to mercury in exterior latex paints after the two remaining companies that had registrations failed to provide EPA with the data necessary to assess potential risks and benefits of using mercury in their product (EPA, 1991).

In September 2005, the MDCH promulgated rules requiring clinical laboratories to report all clinical test results of mercury in blood and urine, under the statutory authority of the Public Health Code (discussed in **Chapter 3.5**). Like other public health surveillance systems, the system built on this reporting requirement includes collection of sufficient information about tested individuals and their health care providers to conduct follow-up to identify the source of exposure, which then triggers public health actions to mitigate exposures to others, if appropriate. The reporting requirement, which also includes reporting of clinical test results for arsenic, cadmium, and cholinesterase, was established so that the MDCH could improve on the tracking and mitigation of human health impacts of environmental exposures to metals and cholinesterase-inhibiting pesticides. In the first full year of reporting (2006) MDCH received over 4,500 clinical laboratory reports of mercury tests in blood and urine. About half of the tests did not find any detectable levels, and most of the rest were within the normal range. Follow-up is underway for the 30 test results that were higher than normal.

Nationally, during the five-year period between 2001 and 2005, there were three deaths and over 16,000 human exposures to Hg(0) reported to poison control centers that did not involve thermometers. In 2001 alone, there were over 17,000 Hg(0) exposures nationally from broken thermometers and 43% of these exposures were in children less than 6 years of age (Caravati, et al., 2007). Because of concerns on the widespread possible locations of Hg(0) exposure, the American Association of Poison Control Centers and the Health Resources Services Administration, Department of Health and Human Services recently released the "*Elemental Mercury Exposure: An Evidence-Based Consensus Guideline for Out-of-Hospital Management*." (See **Chapter 2.6** for additional information on mercury spills).

1.4 BENEFITS AND COSTS DISCUSSION

Much of the risk/benefit analysis for reduction of MeHg has focused on the impacts attributable to power plant emissions. Prevention of neurodevelopment effects, lost productivity, and prevention of cardiovascular effects are a few of the endpoints that researchers have attempted to monetize. Some of this valuation data was included in EPA's cost effectiveness analysis for their Clean Air Mercury Rule (CAMR). The MDEQ Mercury Utility Workgroup report also contains a summary of such data. Differences in health

outcomes evaluated, exposed populations, and dose-response assumptions have resulted in a wide range of benefit values. Economic impacts on the recreational fishing industry have also been evaluated.

Monetizing health outcomes is especially complicated since good health has intrinsic public value that defies cost/benefit valuations. Other "externalities" that are difficult to measure include culture losses and reduced biodiversity. In addition, health outcomes may be hard to assess in individuals, but have drastic implications for society as a whole over time. For example, an individual with an average IQ (intelligence quotient) who loses 5 IQ points due to MeHg exposure may not be significantly impacted. But a shift of 5 points in the bell curve for population IQ increases the percentage of individuals in the mentally retarded range and decreases the percentage of individuals in the mentally gifted range (Mahaffey, 2004). This is why some countries have avoided cost/benefit analyses altogether, instead opting to adopt a precautionary approach toward mercury reduction.

1.4.1 RECREATIONAL AND CULTURAL IMPACTS

In addition to posing threats to human and wildlife health, mercury contamination of the environment can also impact recreational activity and, in turn, have significant economic impacts for Michigan as well as the Great Lakes' commercial fisheries.

Sport fishing is a popular activity, both nationwide and in Michigan. The most recent U.S. Fish and Wildlife Service review of the issue indicated that over 1.3 million anglers fished in Michigan in 2001. The American Sportfishing Association (2002) estimated that the overall economic impact of sport fishing in Michigan (including vehicle purchases, prorated based on fishing activity) in 2001 was nearly $2.2 billion. Some research has indicated that the presence of fish consumption advisories does affect individual's choices about where they fish. For example, a study in Chesapeake Bay found that 36% of the anglers polled would change their fishing location as a result of a fish consumption advisory (Jakus et al., 2002). Therefore, any substantial loss of Michigan's sport fishing activity due to fish advisories could adversely impact Michigan's economy.

On March 19, 2004, the EPA and the U.S. Food and Drug Administration (FDA) issued a joint consumer advisory about mercury in fish and shellfish.[14] This is the first time FDA and EPA have combined their advice into a single uniform advisory. According to EPA, at the end of 2006 there were 48 states that had issued mercury advisories.[15] On October 15, 2007, Alaska issued an epidemiology bulletin, titled *Fish Consumption Advice for Alaskans: A Risk Management Strategy to Optimize the Public's Health* making them the 49th state to issue an advisory for mercury in fish.[16]

While the purpose of fish consumption advisories is to protect the public health, these advisories do not fully achieve that purpose. Surveys of anglers have revealed that even with wide-spread publication of advisories, many anglers are not fully aware of the dangers of eating mercury contaminated fish. It is estimated that as many as 69% of anglers consume their catch, despite fish advisories (Jakus et al., 2002). Additionally, the exposure pathways, risk factors, and cultural impacts unique to Native American populations are not typically factored into risk analysis and permit considerations of non-Native governments. EPA's regulatory impact assessment analysis for the federal utility mercury rule attempted to estimate the benefits of CAMR to this heightened exposure subset of the population, focusing on consumption of freshwater fish.

[14] Information on the EPA/FDA joint venture is available at http://epa.gov/waterscience/fish/advisory.html.
[15] Additional information on fish advisories is available at http://www.epa.gov/ost/fish.
[16] Fish facts and guidelines for Alaskans is at http://www.epi.hss.state.ak.us/eh/fish/default.htm#advice.

The Great Lakes Basin is home to Native American communities (Potawatomi/ Bodwewaadamii, Odawa/Ottawa, and Ojibwa/Chippewa Bands who collectively refer to themselves as the Anishinaabek) who have resided in the Great Lakes region, as independent sovereign nations, for hundreds of years prior to the formation of the state of Michigan (shown in **Figure 1-3**). Native American communities and reservations, both historically and today, are located on or near the Great Lakes in order to retain their cultural identity and to provide Tribal members access to fisheries and other natural resources. Despite assimilation and modernization, most Native American communities continue to struggle to hold onto their culture by retaining a close connection, both physically and spiritually, with the resources of the Great Lakes Basin. Given their unique culture and lifestyle, native populations have a greater potential for mercury exposure, but such contamination also impacts the integrity of ceremonial and cultural practices which depend upon "pure" air, water, plants, and all animal life. Many Native Americans within Michigan and the Great Lakes Region continue to depend upon fishery resources for subsistence and Native American communities tend to consume substantially more fish, both in amount and frequency, than the general population.

In addition to the impacts on Native American culture, a number of studies have indicated higher fish consumption rates among people of color. An earlier study of licensed Michigan anglers found higher fish consumption rates among Latino, African-American, and Native American anglers than white anglers (West et al., 1992; cited in Beehler et al., 2003). Costs, both economic and social, associated with any changes to consumption of fish by subsistence fishing are not well understood and therefore are not well quantified by any cost-benefit analyses (Swain et al., 2007).

1.4.2 BENEFITS

The following information describes various studies and/or attempts made to quantify the benefits in dollars from reducing mercury emissions from coal-fired EGUs.

EPA'S CAMR

In the EPA's final CAMR released March 15, 2005, the benefits of reduced mercury emissions from the utility sector were estimated based on monetized "improvements in IQ decrements" for a subset of the U.S. population exposed *in utero* which included the freshwater angler population (women of childbearing age) in the eastern half of the U.S. EPA also analyzed a smaller subset of the population who consume greater amounts of fish than the general population, which included subsistence fishers, certain Native Americans, and Asian Americans (EPA, 2005c). EPA's analysis indicated that only freshwater fish are significantly impacted by U.S. power plants. EPA did recognize, however, that ocean fish consumption is the predominant pathway for MeHg exposure in the U.S. (approximately 90%) (EPA, 2005c; Section 10-144). EPA stated that

> "exclusion of these commercial pathways means that this benefit analysis, while covering an important source of exposure to domestic mercury emissions excludes a large and potentially important group of individuals."

EPA's benefit estimates represent the monetary values of expected IQ improvements (assessed in terms of future foregone earnings) after reductions are achieved via the final CAMR. This considered, EPA assessed exposure reductions for each of the regulatory options utilizing various control scenarios, timelines, and lag times between reductions and subsequent benefits. EPA's core analysis used a primary dose-response curve that implies that each 1 parts per million (ppm) increase in mercury in hair results in a 0.13 IQ decrement. The monetized value of avoided IQ decrements was estimated to be between $0.8 and $3.0 million annually at a 3% discount rate

(1999 dollars), under CAMR Option 1 assuming no neurotoxicity threshold. Combined benefits of EPA's Clean Air Interstate Rule and CAMR resulted in a range of estimated benefits between $10.4 to $46.8 million annually (1999 dollars) (EPA, 2005c). The benefits associated with each of the emission reduction scenarios were estimated as the difference (reduction) in the total value of IQ losses, going from the relevant baseline scenario to conditions with emissions reductions in place (EPA, 2005c). EPA recognized that full scale IQ might not be the cognitive endpoint that is most sensitive to prenatal mercury exposure (EPA, 2005c). They stated that their benefits assessment has several known uncertainties and biases and that these biases are both in the upward and downward direction but that, taken together

> "…the Agency believes that the benefits presented in this section likely underestimate the total benefits of reducing mercury emissions from power plants due to the potential health effects and potentially exposed populations that are not quantified in this analysis."

In addition to quantifying benefits based on IQ improvements, EPA acknowledged that other health and ecosystem benefits (other neurological effects besides IQ, cardiovascular, genotoxic, immunotoxic, and ecological) may also result from reductions.

It should be noted that the General Accounting Office (GAO) was asked to assess the usefulness of EPA's economic analysis for decision making. The GAO identified four major shortcomings in the economic analysis underlying EPA's proposed mercury control options that limit its usefulness for informing decision makers about the economic trade-offs.[17] As stated in the GAO's February 2005 report, "*Observations on EPA's Cost-Benefit Analysis of Its Mercury Control Options*," they found EPA did not:

1. consistently analyze each of its two mercury policy options or provide estimates of the total costs and benefits of the two options, making it difficult to ascertain which policy option would provide the greatest net benefits.
2. document some of its analysis or provide consistent information on the anticipated economic effects of different mercury control levels under the two options.
3. estimate the economic benefits directly related to decreased mercury emissions.
4. analyze some of the key uncertainties underlying its cost-and-benefit estimates.

The GAO had recommended that prior to finalizing a rule, EPA should take steps to address these shortcomings to increase the usefulness of the analysis for decision making. In commenting on the report, EPA said that it plans to largely address GAO's recommendations.

HARVARD CENTER FOR RISK ANALYSIS

In a separate analysis, researchers from the Harvard Center for Risk Analysis, on contract with the Northeast States for Coordinated Air Use Management (NESCAUM), assessed the health benefits of reducing mercury from U.S. coal-fired EGUs based on targeted emission amounts similar to those EPA had proposed in their draft maximum achievable control technology (MACT) standards (Rice and Hammitt, 2005). The health effects considered in this analysis were "cognitive abilities" (including IQ), and also cardiovascular effects which were not monetized by EPA (EPA, 2005c). They utilized a cost-of-illness approach to derive a value of $16,500 (year 2000 dollars) for each IQ

[17] Details are on the GAO website at http://www.gao.gov/cgi-bin/getrpt?GAO-05-252.

decrement. Their results indicate average national benefits due to prevention of IQ decrements alone in the annual birth cohort ranged between $75 and $194 million (after the MACT Phase I 26 ton cap) and between $119 and $288 million (after the MACT Phase II 15 ton cap), depending on whether or not a neurotoxicity threshold is assumed (all dollar values are for year 2000).[18]

TRASANDE (ET AL.) STUDIES

Trasande et al. (2005) used national blood mercury prevalence data from the CDC to estimate the number of children with blood mercury levels above the RfD. They then estimated the resulting loss of IQ and diminished economic productivity over the lifetimes of the exposed children to come up with a total cost of MeHg toxicity of $8.7 billion annually (range = $2.2-$43.8 billion/yr 2000 U.S. dollars worldwide and $0.4 to 16 billion in the U.S.). Another study by Trasande et al. (2006) estimated that 1,566 excess cases of mental retardation annually (376 to 14,293) are attributable to prenatal exposure of MeHg. This represents 3.2% of all mental retardation cases in the U.S. (range = 0.8 to 29.2%) at a cost of $2.0 billion/yr (range = $0.5 to 17.9 billion/yr). Using the Trasande et al. study, an estimate of children born in Michigan that have cord blood that exceeds 5.8 µg/L (which is the concentration in maternal blood assuming a 1:1 cord blood to maternal blood ratio [Mahaffey, 2004]) can be estimated, based on 7.8 to 15.7% of the total U.S. birth cohort with cord blood > 5.8 µg/L and Michigan births being 3% of that. Approximately 10,000 to 20,000 children born in Michigan in 2005 could have cord blood mercury levels greater than 5.8 µg/L placing these children at risk for neurological deficits.

There have been other studies that estimate the costs associated with the loss of IQ points from exposure to other toxic pollutants with a similar end point (like lead) in the U.S. which generally agree with the costs presented here for mercury (including Grosse et al. [2002] that estimated the cost at $14,500/IQ point and Muir and Zegarac [2001] at $15,000/IQ point).

Additionally, costs on wildlife and ecosystems have not been estimated and this cost estimate, if made, would provide a more realistic picture of impacts to Michigan. Studies that exclude such benefits of protecting wildlife and ecosystems will underestimate the full benefits of mercury reduction (Swain et al., 2007).

1.4.3 COSTS OF CONTROLS

There have been several recent studies that demonstrate that costs for mercury control will continue to decrease over the years as technology improves. The cost of controlling mercury from coal-fired EGUs can be up to 50% less than the 1999 baseline estimates, according to an economic analysis from the U.S. Department of Energy (DOE) based on activated carbon injection (ACI) (Jones et. al., 2007).

DOE has estimated that the costs have decreased from the DOE 1999 baseline from $50,000–70,000/lb of mercury removed to costs ranging from $3,810 to $86,000/lb removed with an outlier in the data being up to $166,000/lb mercury removed. As much as 50% less, plus or minus 30%, than what was predicted in 1999. The plant that cost $166,000/lb to control mercury was unique to the overall data set because the plant had to use a significant amount of activated carbon to control their emissions, which was the exception compared to other plants. At that plant, an unhalogenated activated carbon was used rather than a halogenated activated carbon which DOE is getting better results with as compared to unhalogenated type. The study found that western coal, which has very low chlorine levels and emits higher amounts of Hg(0) was more easily

[18] Details on quantifying mercury cost impacts are in the *Michigan Mercury Electric Utility Report* (2005).

controlled with ACI impregnated with bromine. A Michigan facility was highlighted in this publication (St. Clair DTE Energy) that estimated their cost at $26,200/lb of mercury controlled at 90% using a halogenated activated carbon (Jones et al., 2007) (see **Table 7-2**).

DOE also calculated the increased cost of electricity, finding it varied from 0.14 to 3.92 mills per kilowatt-hour. Their overall conclusion is that costs of controls are decreasing for coal-fired EGUs. DOE released another report in 2007 that updates their economic analysis for ACI (DOE, 2007).[19] DOE's long-term goal is to develop advanced mercury control technologies to achieve 90% or greater capture that would be available for commercial demonstration by 2010.

The Michigan Mercury Electric Utility Workgroup in 2007 has agreed to utilize a baseline from the EPA's I999 Information Collection Request (ICR) database for Hg in coal burned at Michigan facilities. It is estimated based on the concentration in the coal that approximately 3,875 lbs of mercury would be emitted. It is also estimated that Michigan EGUs are currently achieving approximately 0 to 30% mercury control at their facilities.

1.4.4 COSTS OF RECYCLING

Chapter 4.2.7 discusses in depth the Groundwater Stewardship Clean Sweep Program and how this effective recovery program evolved to serve as drop-off locations for liquid Hg(0) and mercury-containing products. Although Clean Sweeps initially targeted farm chemicals, fertilizers and pesticides, they have evolved to accept household hazardous waste and mercury. Small businesses, schools, and the general public can drop off mercury and mercury-containing devices at no charge. For the past five or six years, the mercury collection and disposal (in this case recycling) portion of the program is subsidized by government grants and donations. Given that the sites submit annual invoices and reports to MDEQ, it has been shown that the recycling costs range in the vicinity from $1 to $6/lb for mercury disposal. This price varies since some Clean Sweeps pay an averaged cost across the board for all the hazardous materials they receive. As a result, some may pay a relatively higher cost for materials collected such as paint, but receive a lower price quotation for more hazardous materials such as mercury. In any event, holistically, this range of costs ($1 to $6/lb) represents a highly cost-effective means of capturing mercury and preventing its release to Michigan's environment.

As mercury is collected and consolidated at the Clean Sweep sites, it is later lab packed for shipment. Contractors and/or vendors collect the mercury-containing articles along with other chemicals and materials and transport them off-site for processing. The mercury is eventually sent for triple distillation or retort. Currently a common destination for Michigan mercury is Mercury Waste Solutions, Inc. in Union Grove, Wisconsin. Once recycled and 99.9% pure the mercury is eventually sold on the commodity metals market. D.F. Goldsmith of Chicago, is a large player in this field and sells or brokers mercury world-wide. It is the hope of the MSWG that Michigan mercury is only used in the manufacture of items for which the use of mercury is deemed essential (see discussions in **Chapter 2.5**), such as in fluorescent lamps, but there is no such assurance. Ideally the mercury that is not destined for essential uses will be managed in a way that is permanently sequestered from the environment so as not to be released and contribute to the global pool that is causing concerns in Michigan and throughout the world.

[19] The DOE updated report is at http://www.netl.doe.gov/technologies/coalpower/ewr/mercury/pubs/PhaseII_UPDATED_Hg_Control_Economic_Analysis.pdf.

In summary, the costs of controlling mercury from combustion sources (EGUs) range from approximately $4,000 - $70,000/lb of mercury controlled (Jones et al., 2007). These costs are anticipated to continually decrease as reported by DOE.

Costs for recycling Hg(0) range from $1.00 to 6.00/lb, however this cost does not take into consideration the potential costs related to its final destination and environmental or societal costs (a.k.a. externalities). Because of this, it is not possible to estimate all of the costs associated with recycling Hg(0).

The benefits of controlling mercury have been estimated to range from $1 million to $16 billion dollars annually in U.S. dollars based on IQ decrements and diminished economic productivity over the lifetime of exposed children. However, there is not sufficient information to monetize the benefits to children in Michigan from a reduction in exposure to MeHg.

Costs on wildlife and ecosystems have not been estimated and this cost estimate, if made, would provide a more realistic picture of impacts to Michigan. Studies that exclude such benefits of protecting wildlife and ecosystems will underestimate the full benefits of mercury reduction (Swain et al., 2007).

The most economical means of mercury reduction for products is to avoid adding mercury to a product in the first place (P2 approaches). Once these products enter the waste stream on the surface it appears that recycling is much more cost effective. However, because of many uncertainties related to the associated externalities of a product or process further down the life cycle, it is not possible to quantify the overall costs and benefits to any one specific policy. As mentioned in **Chapter 1.1.1**, a holistic multi-media approach is required that includes consideration of relative risks as well as economic considerations.

2. RELEASES OF MERCURY TO MICHIGAN'S ENVIRONMENT

2.1 AIR

2.1.1 ANTHROPOGENIC SOURCES

Mercury is a naturally occurring element released into the environment from a variety of sources, both natural and anthropogenic (man-made). Anthropogenic derived mercury can be emitted primarily in three forms. These include gaseous Hg(0); reactive gaseous mercury (RGM) consisting of various oxidized gaseous [Hg(II)] compounds; and particle-bound mercury [Hg(p)] consisting of various (commonly unknown) mercury compounds (Lindberg et al., 2007). Research has shown that mercury emitted by human activities can be transported and deposited locally, regionally and globally. All three forms can be deposited (Hg(0) can deposit to foliage), and many complex factors are involved, some of which are not completely understood. Hg(0) is likely to exist in the atmosphere for up to a year, while the RGM and Hg(p) are more readily deposited (Lindberg et al., 2007). (For more discussion on environmental fate, see **Chapter 6**).

STATEWIDE ANTHROPOGENIC MERCURY EMISSIONS INVENTORY

Based on 2002 emissions inventory data (see **Appendix G** for more detail), the largest unregulated source of anthropogenic mercury emissions in Michigan is coal combustion from EGUs, emitting approximately 37% of Michigan's emissions. In 2006, the MDEQ formed a rules workgroup for developing new air pollution control rules to address mercury emissions from coal-fired EGUs that would achieve 90% control by 2015.[20]

While coal-fired EGUs represent the largest air emissions source of mercury, a significant fraction of mercury emissions also come from the use and disposal of mercury-containing products. For example, mercury emissions are released through the melting of steel scrap contaminated with mercury switches/other devices used in automobiles, industrial equipment, and commercial/consumer appliances, and from incineration of municipal, hazardous, and medical waste that includes mercury-containing lamps, batteries, thermometers, thermostats, etc. The following, in descending order, show the source categories of anthropogenic mercury emissions in Michigan:

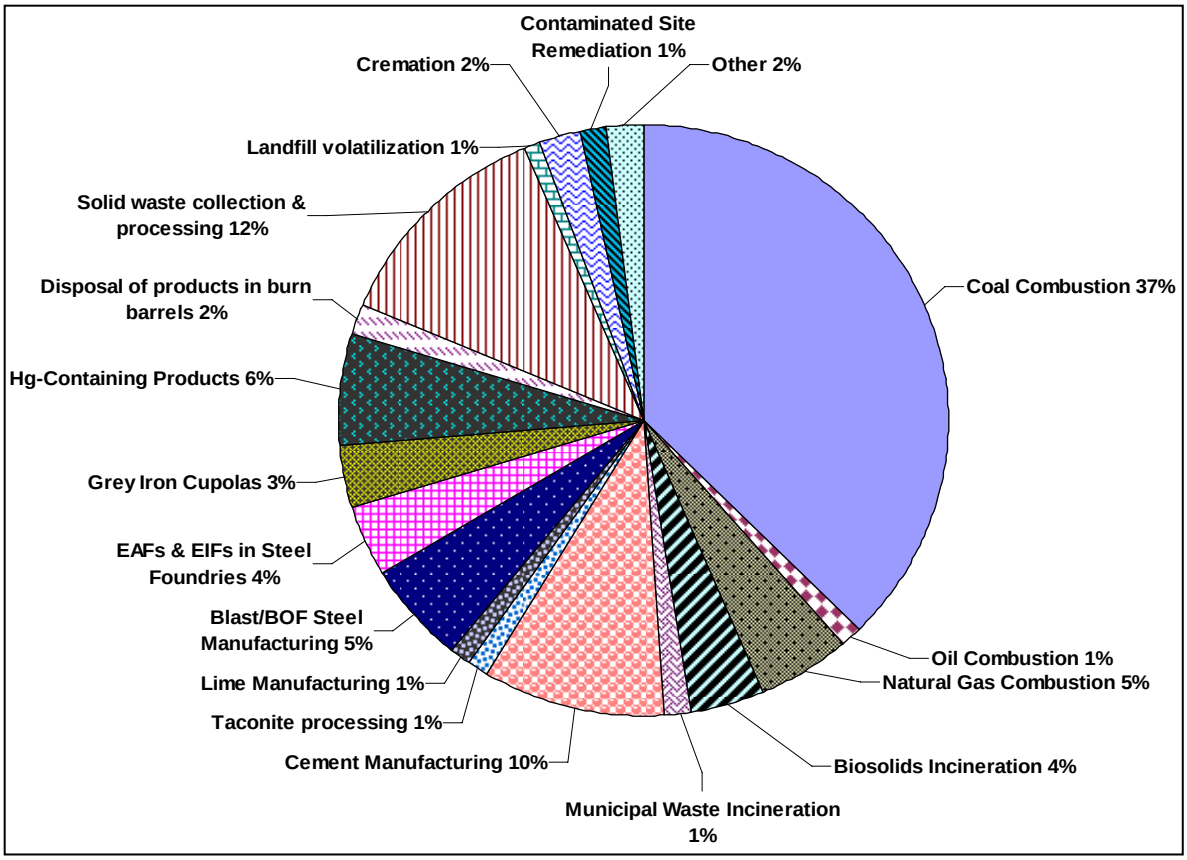
- Coal-fired EGUs (37%)
- Volatilization during solid waste collection and processing (12%).
- Cement manufacturing (10%).
- Mercury-containing products (6%).
- Blast/Basic Oxygen Furnace (BOF) steel manufacturing (5%).
- Natural gas combustion (5%).[21]
- Biosolids incineration (4%).
- EAFs (Electric Arc Furnaces) and Electric Induction Furnaces (EIFs) in steel foundries (4%).
- Other sources account for the remainder (17%).

Figure 2-1 shows the source categories and their 2002 estimated mercury emissions based on the 2002 emissions inventory data. Approximately 60% of the overall annual mercury emissions (approximately 7,000 lbs/yr) released from combustion sources are from naturally occurring or re-emitted mercury in the materials combusted. The remaining 40% is released due to mercury purposefully added to various items.

[20] Details on the Michigan Mercury Rules Workgroup are available at http://www.michigan.gov/deqair.

[21] MDEQ is investigating the accuracy of the natural gas combustion emission factor, which may be an overestimate for this source category. It will likely be revised in the future. See **Table 2-1**.

FIGURE 2-1: 2002 ESTIMATES OF ANTHROPOGENIC MERCURY AIR EMISSIONS IN MICHIGAN BY SOURCE CATEGORY



Note: MDEQ is investigating the accuracy of the natural gas combustion emission factor which may be an overestimate for this source category. It will likely be revised in the future. See **Table 2-1**.

The following **Figures 2-2** and **2-3** represent facilities that emit less than and greater than 50 lbs of mercury per year, respectively.

FIGURE 2-2: FACILITIES THAT EMIT LESS THAN 50 POUNDS OF MERCURY PER YEAR

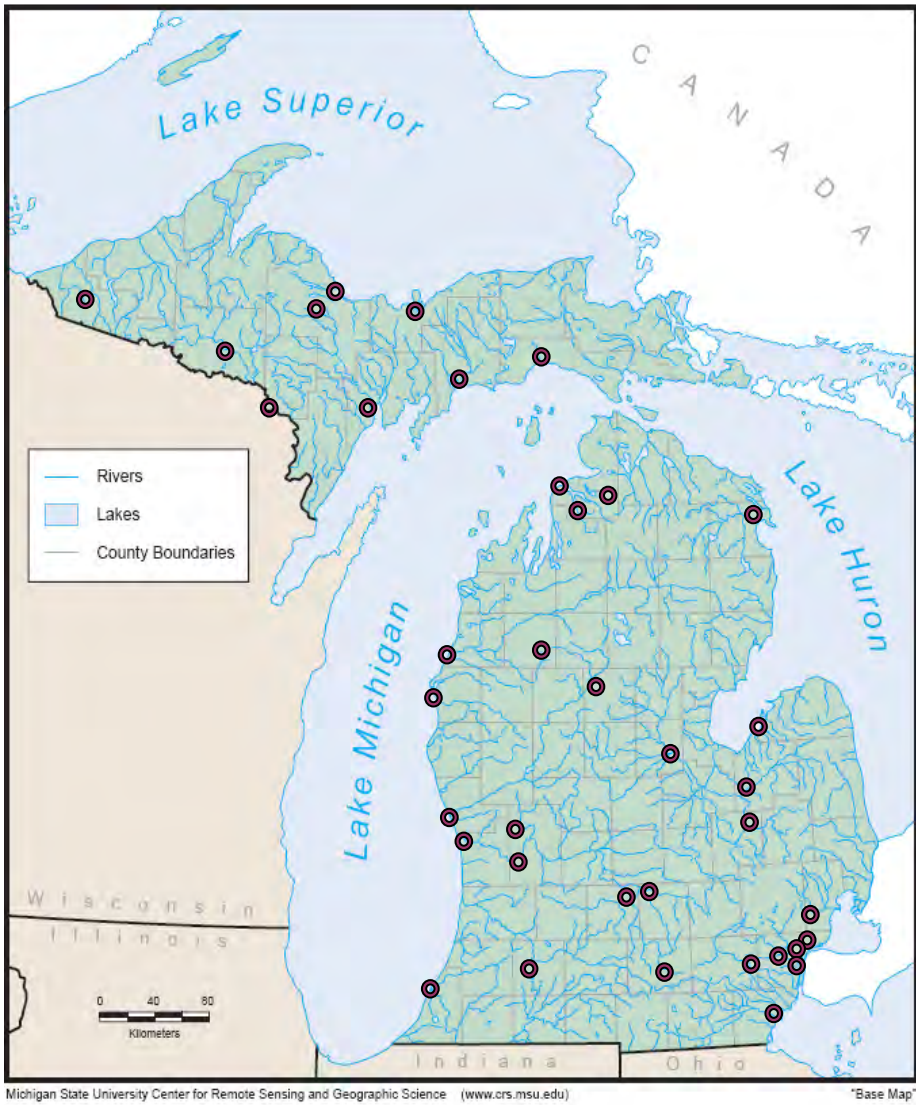
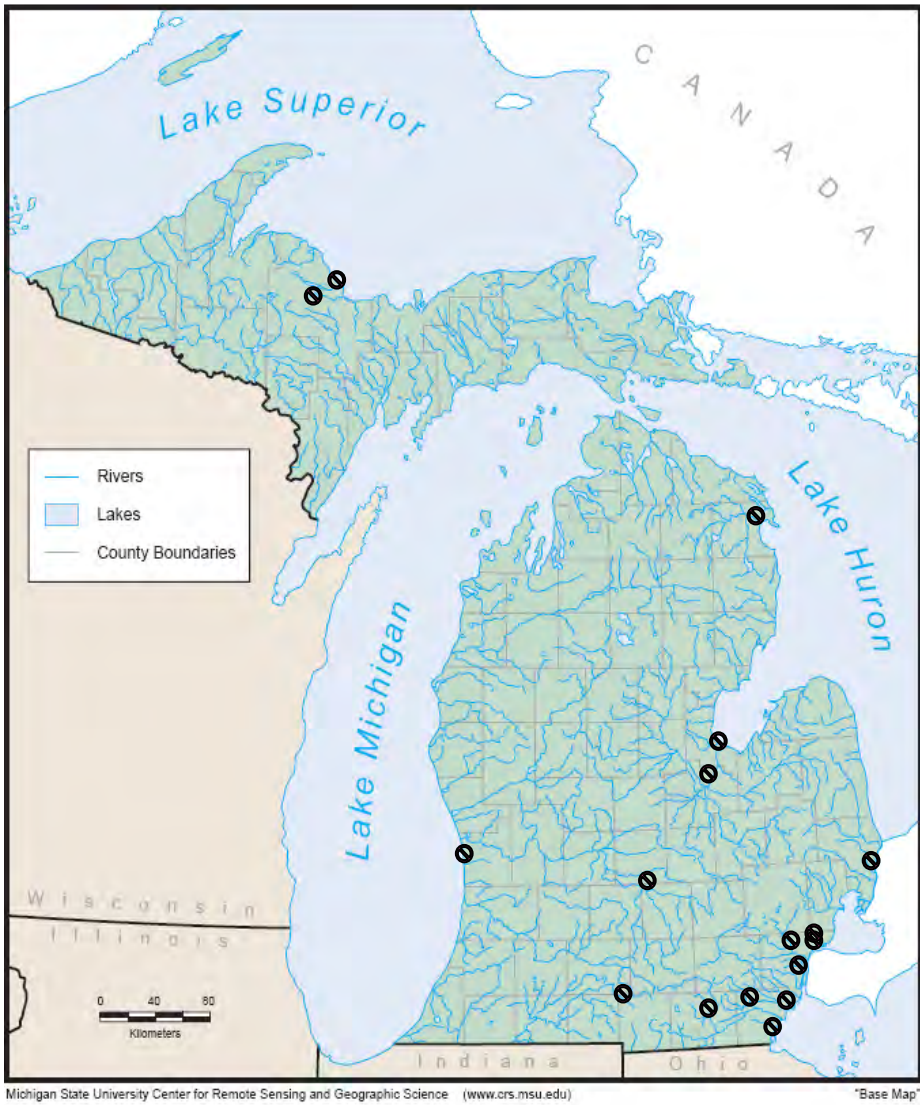


FIGURE 2-3: FACILITIES THAT EMIT GREATER THAN 50 POUNDS OF MERCURY PER YEAR



In **Table 2-1**, the anthropogenic mercury air emissions are shown by emission source utilizing the 2002 emissions inventory. Note: The "italicized text" shows the breakdown of that specific product calculated utilizing the mercury flow model (Minnesota Pollution Control Agency, 2001).[22]

TABLE 2-1: 2002 ESTIMATES OF ANTHROPOGENIC MERCURY AIR EMISSIONS IN MICHIGAN

EMISSION SOURCE	Hg (LBS/YR)	Hg(p)	RGM	Hg(0)
FUEL COMBUSTION				
COAL COMBUSTION				
Electric Utilities	2488	430.0	732.7	1325.7
Residential	1	0.2	0.3	0.5
Industrial/Commercial	213	42.6	63.9	106.5
OIL COMBUSTION				
Electric Utilities	51	10.2	15.3	25.5
Residential	36	7.2	10.8	18.0
Industrial/Commercial Boilers	2	0.4	0.6	1.0
NATURAL GAS COMBUSTION[23]				
Electric Utilities	9	1.8	2.7	4.5
Residential	95	19.0	28.5	47.5
Industrial/Commercial Boilers	19	3.8	5.7	9.5
Stationary Internal Combustion Engines	234	46.8	70.2	117.0
WOOD COMBUSTION				
Electric Utilities	7	1.4	2.1	3.5
Residential/Outdoor Wood Boilers	8			8
Industrial/Commercial	5	1.0	1.5	2.5
PETROLEUM REFINING	5	0.5	0.5	4.0
RESIDENTIAL LIQUID PETROLEUM GAS PROPANE COMBUSTION	4	0.8	1.2	2.0
TOTAL FUEL COMBUSTION	**3177**	**566**	**936**	**1676**
INCINERATION				
Biosolids Incineration	285	57.0	165.3	62.7
Municipal Waste	100	20.0	58.0	22.0
Hazardous Waste Incineration	41	9.0	8.2	23.8
Hospital Waste	3	0.6	2.3	0.2
INCINERATION TOTALS	**429**	**87**	**234**	**109**
INDUSTRIAL SOURCES				
Cement Manufacturing	694	142.8	152.9	398.3
Taconite processing	88	8.8	8.8	70.4
Lime Manufacturing	73	7.3	7.3	58.4
Dental Amalgam Manufacturing	4	0	0	4
Brick Manufacturing	1	0.1	0.1	0.8
Coke Production	3	0.3	0.3	2.4
Thermometer Manufacturing	0	0	0	0
Medical Waste Autoclaves	Unknown	--	--	

[22] The mercury flow model was developed by the Swedish National Chemical Inspectorate and adapted by Barr Engineering for the State of Minnesota and extrapolated for Wisconsin and Michigan. MDEQ used this model and entered Michigan data.

[23] The MDEQ is investigating the accuracy of this emission factor. It may be an overestimate for this source category and will likely be revised in the future.

TABLE 2-1: 2002 ESTIMATES OF ANTHROPOGENIC MERCURY AIR EMISSIONS IN MICHIGAN

EMISSION SOURCE	Hg (LBS/YR)	Hg(p)	RGM	Hg(0)
INDUSTRIAL SOURCES (CONTINUED)				
PRODUCTION OF METALS				
Primary metal production (Blast/BOF Steel Manufacturing)	396	39.6	39.6	316.8
EAFs in primary metal production (Steel Manufacturing)	31	3.1	3.1	24.8
EAFs & EIFs in secondary metal production (Steel Foundries)	282	28.2	28.2	225.6
Cupolas in Secondary metal production (Grey Iron)	228-237	22.8-23.7	22.8-23.7	182.4-189.6
EAFs & EIFs in Secondary metal production (Grey Iron)	7-28	0.7-2.8	0.7-2.8	5.6-22.4
INDUSTRIAL SOURCE TOTALS	**1807-1837**	**254-257**	**264-267**	**1290-1314**
AREA SOURCES				
MERCURY-CONTAINING PRODUCTS				
Dental Amalgam	141	0	0	141
Auto Switches-shredding of autos	117	11.7	11.7	93.6
Switches & Relays (includes thermostats)	96	0	0	96
Measurement and Control Devices (includes thermometers)	61	0	0	61
Consumer Use of Bulk Mercury	20	0	0	20
Thermostats	*15*			
Fluorescent Lamp Breakage	9	0	0	9
Fluorescent Lamp Recycling	4	0	0	4
Non-fluorescent Lamp Breakage	2	0	0	2
WASTE DISPOSAL				
Volatilization during solid waste collection & processing	877	87.7	87.7	701.6
Fluorescent lamps	*101*			
Switches and Relays (includes thermostats)	*42*			
Measurement and Control Devices (includes thermometers)	*42*			
Thermometers	*24*			
Thermostats	*20*			
Non-fluorescent lamps	*9*			
Bulk Mercury	*7*			
Dental Amalgam	*4*			
Landfill volatilization	68	6.8	6.8	54.4
Switches and Relays (includes thermostats)	*13*			
Measurement and Control Devices (includes thermometers)	*13*			
Non-fluorescent lamps	*9*			
Thermostats	*7*			
Fluorescent lamps	*7*			
Dental Amalgam	*2*			
Thermometers	*2*			
Disposal of products in burn barrels	124	24.8	37.2	62
Switches and Relays (includes thermostats)	*55*			
Measurement and Control Devices (includes thermometers)	*54*			

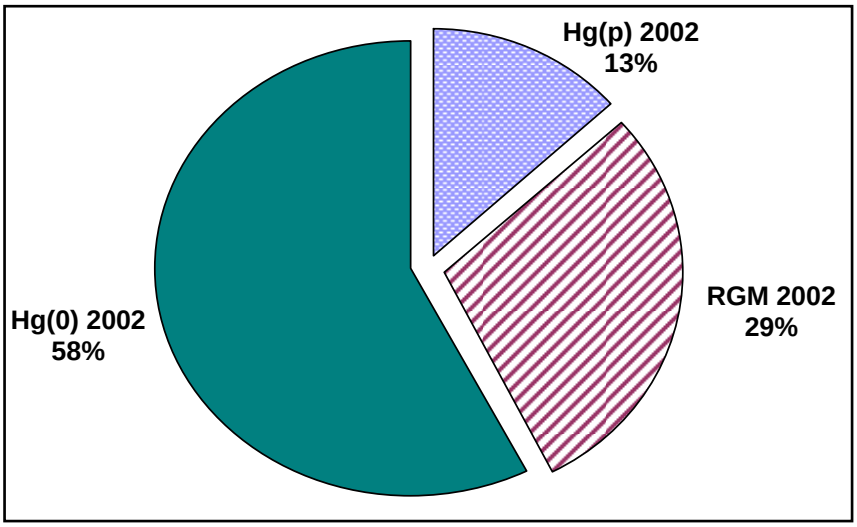
TABLE 2-1: 2002 ESTIMATES OF ANTHROPOGENIC MERCURY AIR EMISSIONS IN MICHIGAN

EMISSION SOURCE	Hg (LBS/YR)	Hg(p)	RGM	Hg(0)
AREA SOURCES (CONTINUED)				
WASTE DISPOSAL (CONTINUED)				
Thermostats	*29*			
Fluorescent lamps	*13*			
Thermometers	*7*			
Non-fluorescent lamps	*2*			
Autoclaves	unknown			
Cremation	126-189	25.2-37.8	73.1-109.6	27.7-41.6
Disposal of Bulk Hg to Clean Sweep Sites	7	0	0	7
Volatilization: land application of sludge	5	0.5	0.5	4
Contaminated Site Remediation	96	9.6	9.6	76.8
AREA SOURCE TOTALS	**1753-1816**	**166-179**	**227-263**	**1360-1374**
MOBILE SOURCES				
On Road	0.17-0.47	0.03-0.09	0.10-0.27	0.04-0.10
Non-Road	0.2-10.0	0.04-2.0	0.12-5.8	0.04-2.2
MOBILE SOURCE TOTALS	**0.37-10.5**	**0.07-2.1**	**0.22-6.1**	**0.08-2.3**
TOTAL Hg AIR EMISSIONS	**7158-7269**	**1072-1090**	**1660-1706**	**4426-4475**

(See **Appendix G** – *2002 Estimates of Anthropogenic Mercury Air Emissions in Michigan* for source data and the methods used to calculate total mercury emissions. Speciation percentages were derived from EPA, 2006a.)

Figure 2-4 shows the distribution of the three forms of mercury utilizing the source data from the *2002 Estimates of Anthropogenic Mercury Air Emissions in Michigan*.

FIGURE 2-4: MICHIGAN'S DISTRIBUTION OF MERCURY FROM THE 2002 ANTHROPOGENIC MERCURY AIR EMISSIONS INVENTORY



Coal combustion is the largest source of anthropogenic mercury emissions nationally and in Michigan. A decrease of coal combustion would result in a decrease of mercury air emissions. Such a decrease could result from conservation programs, energy efficiency measures and an increase in renewable energy. The Governor's *21st Century Energy Plan* supports the enhancement of Michigan's ability to power itself through the use of renewable resources, energy efficiency measures, and the cleanest available utility-built generation by making investment in baseload generation, fostering

investment in energy efficiency programming and renewable energy, and adopting procedures to enable the use of emerging technologies (see **Chapter 5.1** for additional information).[24]

2.1.2 NATURAL SOURCES

Michigan Forest Fire-Photo Courtesy of US National Interagency Fire Center

While few natural mercury emission sources exist in Michigan, natural emissions do occur elsewhere and can be transported and deposited within the state. Natural terrestrial sources include forest fires, volcanoes, geothermal areas, naturally mercury-enriched and "background" soils, and vegetation (known background levels in Michigan can be found in **Appendix F**). While mercury is not typically a health concern in soil and vegetation, fire releases mercury from the trees and forest floor to the atmosphere where it can be transported to other locations. Atmospheric mercury can stay in the air for up to two years, circling the globe and eventually depositing even in remote bodies of water, where it can be transformed to the highly toxic MeHg that builds up in fish (Sigler et al., 2003). Emissions from "background" soils (soils that have low concentrations of mercury [<0.1 ppm] and have not been enriched by geologic processes), forest fires, and vegetation are predominately re-emissions of previously deposited atmospheric mercury derived from natural and anthropogenic sources (Gustin and Lindberg, 2005). In a more recent study, it was found that forest fires release more mercury into the atmosphere than previously recognized. This is due to the fact that forests act as mercury traps because mercury in the atmosphere collects on foliage. When the foliage dies, it falls to the forest floor and decomposes, and the mercury enters the soil. Because it binds strongly to organic molecules, mercury is most prevalent in the top several inches of soil, where organic matter is concentrated. By comparing the mercury content of burned soil with that of unburned soil, researchers can estimate how much mercury was released when forests burned (Biswas et al., 2007). **Table 2-2** provides a summary of natural sources, some possible re-emissions, and their estimated global mercury emissions.[25]

TABLE 2-2: SUMMARY OF ESTIMATED EMISSION OF NATURAL AND RE-EMITTED MERCURY

SOURCE	RANGE IN GLOBAL EMISSIONS (TONS/YR)	REFERENCES
Volcanoes	104-771	Nriagu and Becker, 2003; Mather and Pyle, 2004
Geothermal	66	Varenkamp and Busek, 1984
Naturally Enriched Soil	>1653	Gustin and Lindberg, 2005
Re-emission from Vegetated Ecosystems*	Forests: 937 to 2204 Grasslands: 882 to 2535	Lindberg et al., 1998; Obrist et al., 2004
Re-emission via Forest Fires*	220 to 1102	Brunke et al., 2001; Friedli et al., 2001

*Re-emissions could originate from natural or anthropogenic emissions.

While it is difficult to determine the proportion of anthropogenic and natural mercury sources contributing to current environmental levels, current studies suggest that natural sources of mercury account for approximately one-third of total global mercury emissions. As summarized in the following **Table 2-3**, anthropogenic sources and re-emissions of previously-deposited anthropogenic atmospheric mercury account for the

[24] Information on *Michigan's 21st Century Energy Plan* is available at http://www.michigan.gov/mpsc and http://www.michigan.gov/documents/mpsc/21stcenturyenergyplan_185274_7.pdf .
[25] Information modified from Gustin and Lindberg, 2005

remaining two-thirds (2/3) of global mercury emissions (Dastoor and Larocque, 2004; Pirrone, 2001; Jackson, 1997; Lamborg et al., 2002b). Re-emission of previously-deposited atmospheric mercury released from diffuse secondary sources in the environment is poorly quantified (Jackson, 1997; Gustin and Lindberg, 2005). Re-emission was previously thought to primarily be from anthropogenic mercury, but recent literature suggests that a significant proportion of re-emitted mercury could be re-emitted from natural sources (Gustin and Lindberg, 2005; Dastoor and Larocque, 2004; Lamborg et al., 2002b).

A recent panel of experts cautioned against using the phrase "global background" as it creates confusion regarding the contribution of anthropogenic emissions to deposition. The global atmospheric pool of mercury is a mixture of mercury emitted from all sources (both natural and anthropogenic) and is dominated by primary and secondary anthropogenic emissions, even at the most remote locations. Global background concentrations of Hg(0) at remote sites is currently taken as ~1.5-1.7 ng/m^3 in the Northern Hemisphere and ~1.1-1.3 ng/m^3 in the Southern Hemisphere. The term "global sources" should be avoided, because "all sources are local" but have the capacity to contribute to the global pool (Lindberg et al., 2007). **Table 2-3** provides a range of global emissions from various atmospheric mercury sources.[26]

TABLE 2-3: SUMMARY OF GLOBAL FLUX ESTIMATES FOR THE SOURCES OF ATMOSPHERIC MERCURY

SOURCE	RANGE IN GLOBAL EMISSION ETIMATES (TONS/YR)	WORKING ESTIMATE[1]	REFERENCES
Anthropogenic	~ 2200 – 2600	2400 (1/3 of Total)	Bergan et al., 1999; Mason and Sheu, 2002; Lamborg et al., 2002b; Seigneur et al., 2004
Natural Emissions and Re-Emissions	~ 880 - 3300	2400 (1/3 of Total)	Nriagu, 1989; Mason et al., 1994; Mason and Sheu, 2002; Lamborg et al., 2002b; Seigneur et al., 2001; Bergan et al., 1999
Re-Emissions of Anthropogenic	~ 2400 – 3520	2400 (1/3 of Total)	Estimated by difference
Total Emissions	~ 6600 - 7300	7200	Bergan et al., 1999; Mason and Sheu, 2002; Lamborg et al., 2002b; Seigneur et al., 2004

[1] This working estimate was created for use in this document.

Studies examining records from lake sediments suggest that human activity has increased mercury levels in the environment by three- to five-fold (Fitzgerald et al., 1998; Lamborg et al., 2002b; Lindberg et al., 2007).

Gas-phase mercury concentrations in the ambient air in areas of the Great Lakes Basin range from 1.0 to 3.5 ng/m^3 for gas-phase mercury and from 1 to 100 pg/m^3 for particulate-phase mercury (Burke, 1998; Keeler and Dvonch, 2005).

2.2 WATER

2.2.1 MERCURY IN LAND APPLIED BIOSOLIDS

The term "Biosolids" is defined as solid, semisolid, or liquid residues generated during primary, secondary, or advanced treatment of domestic sanitary sewage through one or more controlled processes that reduce pathogens and attractiveness to vectors (flies, mosquitoes, rodents). These processes include, among others, anaerobic digestion, aerobic digestion, and lime stabilization. Biosolids (also known as sewage sludge) are

[26] Information modified from Gustin and Lindberg, 2005.

used to enhance agricultural and forestry production in Michigan. Almost all biosolids that are land applied are used to grow crops on sites at agronomic application rates approved by the MDEQ. Biosolids are also used to provide nutrients and soil conditioning in mine reclamation programs, tree farms, and forest lands. The picture on the right was taken the summer after biosolids were applied under a mine reclamation program. As shown, the area on the left received biosolids and the right side did not.

Once mercury enters a wastewater treatment plant (WWTP), most of it concentrates in wastewater biosolids during treatment which is disposed of by land spreading.[27] Some of this land-applied mercury may, over time, be volatilized to the atmosphere which can then be deposited into lakes and streams, methylated, and ingested by fish, eventually reaching wildlife and humans. The term biosolids is related to the definition of sewage sludge found in Part 31, Water Resources Protection of the Natural Resources and Environmental Protection Act (NREPA), 1994 PA 451, as amended. However, biosolids are only that portion of sewage sludge that have undergone adequate treatment to permit their application to land. R 323.2405 of the Michigan Administrative Code (MAC) excludes industrial sludge or septage from regulation as biosolids. **Table 2-4** lists the average mercury concentrations that are found in Michigan's biosolids.

TABLE 2-4: AVERAGE MERCURY CONCENTRATIONS IN MICHIGAN BIOSOLIDS, VOLUME OF BIOSOLIDS LAND-APPLIED, AND THE RESULTING MERCURY LOAD

YEAR	AVERAGE HG CONCENTRATION IN BIOSOLIDS (mg/kg)	LAND-APPLIED BIOSOLIDS (DRY TONS)	HG RELEASE VIA LAND-APPLIED BIOSOLIDS (lbs)
1997	2.00	112,000	2160
1998	2.22	93,400	2010
1999	2.36	79,400	1820
2000	3.01	80,200	2340
2001	3.41	80,900	2670
2002	3.39	82,100	2700
2003	1.90	71,900	1320

2.2.2 MERCURY RELEASES TO SURFACE WATERS

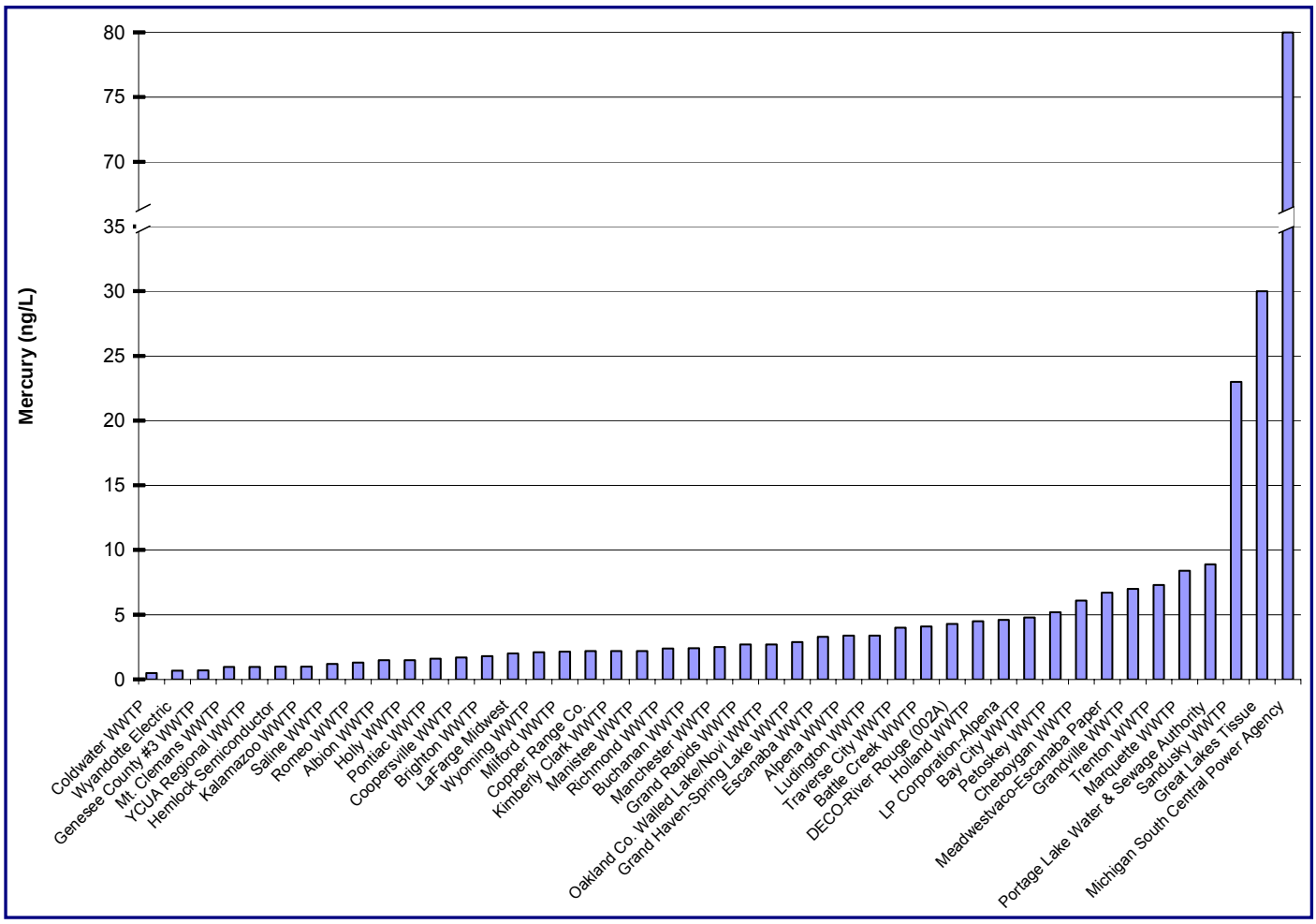
As shown in **Table 2-5**, there are at least 45 individual NPDES permits for WWTP and/or facilities that contain mercury limits and/or low-level monitoring requirements (MDEQ, 2004). Low-level mercury analyses continue to indicate that the level of mercury in many point source discharges can be expected to routinely exceed the WQS of 1.3 nanogram per Liter (ng/L) (see **Chapter 3.2** regarding water regulations). However, at the time the *Mercury Water Discharge Permitting Strategy* was developed (discussed in **Chapter 3.2.1**), data obtained from compliance monitoring for point source discharges indicate that 42 out of 45 facilities with mercury limits or monitoring requirements have arithmetic mean mercury concentrations below 10 ng/L, with 35 facilities less than 5 ng/L (shown in **Figure 2-5**).

[27] Biosolids are only that portion of sewage sludge that have undergone adequate treatment to permit their application to land.

TABLE 2-5: SUMMARY OF MERCURY DATA AVAILABLE (THRU 2003) FOR MICHIGAN NPDES PERMITTED FACILITIES

FACILITY	PERMIT NUMBER	COUNTY	N	ARITHMETIC MEAN (ng/L)	MEDIAN (ng/L)	RANGE (ng/L)
Albion WWTP	MI0022161	Calhoun	17	1.5	1.3	<0.5 - 5.7
Alpena WWTP	MI0022195	Alpena	12	3.4	3.0	1.8 - 5.5
Battle Creek WWTP	MI0022276	Calhoun	18	4.1	2.9	<0.5 - 9.8
Bay City WWTP	MI0022284	Bay	3	4.8	4.7	1.0 - 8.7
Brighton WWTP	MI0020877	Livingston	3	1.8	1.8	1.7 - 2.0
Buchanan WWTP	MI0022489	Berrien	10	2.4	2.2	1.0 - 5.7
Cheboygan WWTP	MI0020303	Cheboygan	5	6.1	6.4	2.9 - 8.6
Coldwater WWTP	MI0020117	Branch	4	0.5	0.6	<0.5 - 0.9
Coopersville WWTP	MI0022730	Ottawa	24	1.7	1.6	<0.5 - 4.6
Copper Range Co.	MI0006114	Ontonagon	15	2.2	1.4	<0.5 - 7.6
DECO-River Rouge (002A)	MI0001724	Wayne	4	4.3	4.3	<0.5 - 8.6
Escanaba WWTP	MI0025381	Delta	8	3.3	2.9	1.1 - 7.8
Genesee County #3 WWTP	MI0022993	Genesee	7	0.7	0.7	0.6 - 0.9
Grand Haven-Spring Lake WWTP	MI0021245	Ottawa	28	2.9	2.7	1.4 - 5.3
Grand Rapids WWTP	MI0026069	Kent	8	2.7	2.3	1.6 - 6.0
Grandville WWTP	MI0023027	Ottawa	32	7.0	5.1	2.2 - 24.4
Great Lakes Tissue	MI0002496	Cheboygan	6	30.0	27	13.0 - 52.0
Hemlock Semiconductor	MI0027375	Saginaw	7	1.0	0.9	0.8 - 1.3
Holland WWTP	MI0023108	Allegan	39	4.5	3.5	1.0 – 20.0
Holly WWTP	MI0020184	Oakland	8	1.5	1.4	0.9 - 3.3
Kalamazoo WWTP	MI0023299	Kalamazoo	61	1.0	0.8	<0.5 - 4.5
Kimberly Clark WWTP	MI0000892	Alger	12	2.2	1.4	0.7 - 5.2
LaFarge Midwest	MI0001988	Alpena	17	2.0	1.8	<0.5 - 3.8
LP Corporation-Alpena	MI0002500	Alpena	10	4.6	4.1	<0.5 - 9.8
Ludington WWTP	MI0021334	Mason	4	3.4	2.4	2.1 - 6.8
Manchester WWTP	MI0023507	Washtenaw	12	2.5	2.7	0.8 - 5.7
Manistee WWTP	MI0020362	Manistee	25	2.2	1.5	0.9 - 7.5
Marquette WWTP	MI0023531	Marquette	10	8.4	7.2	4.4 - 13.2
Meadwestvaco-Escanaba Paper	MI0000027	Delta	6	6.7	6.5	4.0 - 9.0
MI South Central Power Agency	MI0039608	Hillsdale	15	80.0	60.0	25.0 - 265.0
Milford WWTP	MI0023604	Oakland	4	2.2	2.3	0.8 - 3.2
Mt. Clemens WWTP	MI0023647	Macomb	24	0.9	<0.5	<0.5 - 16.3
Oakland Co Walled Lake/Novi WWTP	MI0024287	Oakland	23	2.7	1.4	<0.5 - 25.4
Petoskey WWTP	MI0023787	Emmet	18	5.2	3.0	1.1 - 20.6
Pontiac WWTP	MI0023825	Oakland	15	1.6	1.6	0.5 - 2.9
Portage Lake Water & Sewage Authority	MI0020061	Houghton	8	8.9	8.7	5.6 - 13.5
Richmond WWTP	MI0023906	Macomb	26	2.4	2.0	0.8 9.5
Romeo WWTP	MI0021679	Macomb	4	1.3	1.0	0.9 - 2.1
Saline WWTP	MI0024023	Washtenaw	17	1.2	1.0	<0.5 - 3.9
Sandusky WWTP	MI0020222	Sanilac	11	23.0	18.0	<0.5 – 53.0
Traverse City WWTP	MI0027481	Grand Traverse	18	4.0	3.6	1.6 – 10.0
Trenton WWTP	MI0021164	Wayne	3	7.3	7.5	2.88 - 11.5
Wyandotte Electric	MI0038105	Wayne	11	0.7	0.6	<0.5 - 2.6
Wyoming WWTP	MI0024392	Kent	17	2.1	2.0	1.2 - 3.2
Ypsilanti Community Utilities Authority WWTP	MI0042676	Washtenaw	4	0.9	0.9	0.5 - 1.5

FIGURE 2-5: ARITHMETIC MEAN EFFLUENT MERCURY CONCENTRATION FOR NPDES PERMITTED FACILITIES



The effluent data were also evaluated using the reasonable potential provisions of the Part 8 Rules, Water Quality-Based Effluent Limit Development for Toxic Substances, pursuant to Part 31, Water Resources Protection, of the NREPA. Reasonable potential is a statistical approach for predicting the expected discharge concentration of a pollutant. There are two approaches for determining reasonable potential:

Approach 1: If 10 or more quantifiable facility-specific effluent samples are available, the predicted average effluent concentration equals the upper 95 percentile of all representative data points;

Approach 2: If less than 10 quantifiable samples are available, the predicted average effluent concentration is equal to the maximum effluent concentration multiplied by a "multiplying factor" provided in R 323.1211.

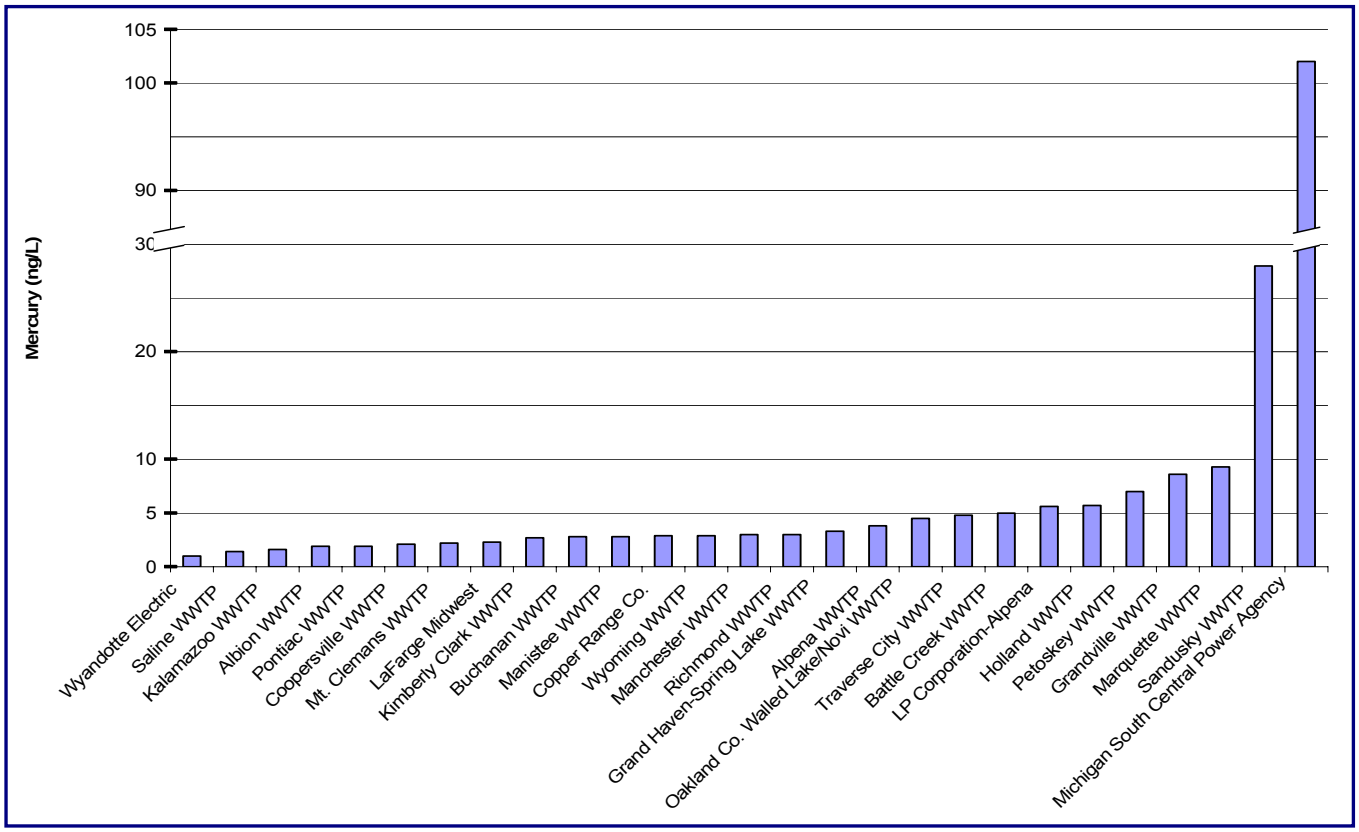
Approach 2 is more conservative than Approach 1 and generally produces higher predicted effluent concentrations. If either approach demonstrates reasonable potential for the discharge to exceed the WQS of 1.3 ng/L, a mercury limit based on the level currently achievable (LCA) will be included in the permit.

The following **Table 2-6** and **Figure 2-6** show that for all facilities (except two) with 10 or more quantifiable data points, the predicted average mercury effluent concentration, calculated using Approach 1, was less than 10 ng/L.

TABLE 2-6: SUMMARY OF AVAILABLE EFFLUENT MERCURY DATA (THRU 2003) FOR MICHIGAN NPDES PERMITTED FACILITIES WITH GREATER THAN OR EQUAL TO 10 QUANTIFIABLE DATA POINTS

FACILITY	PERMIT NUMBER	COUNTY	PREDICTED EFFLUENT CONCENTRATION (ng/L)	N
Albion WWTP	MI0022161	Calhoun	1.9	17
Alpena WWTP	MI0022195	Alpena	3.8	12
Battle Creek WWTP	MI0022276	Calhoun	5.0	18
Buchanan WWTP	MI0022489	Berrien	2.8	10
Coopersville WWTP	MI0022730	Ottawa	2.1	24
Copper Range Co.	MI0006114	Ontonagon	2.9	15
Grand Haven-Spring Lake WWTP	MI0021245	Ottawa	3.3	28
Grandville WWTP	MI0023027	Ottawa	8.6	32
Holland WWTP	MI0023108	Allegan	5.7	39
Kalamazoo WWTP	MI0023299	Kalamazoo	1.6	61
Kimberly Clark WWTP	MI0000892	Alger	2.7	12
LaFarge Midwest	MI0001988	Alpena	2.3	17
LP Corporation-Alpena	MI0002500	Alpena	5.6	10
Manchester WWTP	MI0023507	Washtenaw	3.0	12
Manistee WWTP	MI0020362	Manistee	2.8	25
Marquette WWTP	MI0023531	Marquette	9.3	10
Michigan South Central Power Agency	MI0039608	Hillsdale	102	14
Mt. Clemens WWTP	MI0023647	Macomb	2.2	24
Oakland Co. Walled Lake/Novi WWTP	MI0024287	Oakland	4.5	23
Petoskey WWTP	MI0023787	Emmet	7.0	18
Pontiac WWTP	MI0023825	Oakland	1.9	15
Richmond WWTP	MI0023906	Macomb	3.0	26
Saline WWTP	MI0024023	Washtenaw	1.4	17
Sandusky WWTP	MI0020222	Sanilac	28.0	11
Traverse City WWTP	MI0027481	Grand Traverse	4.8	18
Wyandotte Electric	MI0038105	Wayne	1.0	11
Wyoming WWTP	MI0024392	Kent	2.9	17

FIGURE 2-6: PREDICTED 95TH PERCENTILE FOR DATA SETS WITH GREATER THAN OR EQUAL TO 10 QUANTIFIABLE DATA POINTS



For the 18 facilities with less than 10 quantifiable data points (shown in **Table 2-7**), the predicted effluent concentration, calculated using Approach 2, was less than 10 ng/L for 8 facilities. As additional low-level mercury data are collected for these 18 facilities such that a minimum of 10 quantifiable data points are available, the less conservative reasonable potential approach (Approach 1) will likely predict lower effluent concentrations.

TABLE 2-7: NPDES PERMITTED FACILITY LOW-LEVEL EFFLUENT MERCURY DATA (THRU 2003) WITH LESS THAN 10 QUANTIFIABLE DATA POINTS

FACILITY	PERMIT NUMBER	COUNTY	ARITHMETIC MEAN (ng/L)	PREDICTED EFFLUENT CONCENTRATION (ng/L)	N
Bay City WWTP	MI0022284	Bay	4.8	26.0	3
Brighton WWTP	MI0020877	Livingston	1.8	6.0	3
Cheboygan WWTP	MI0020303	Cheboygan	6.1	20.0	5
Coldwater WWTP	MI0020117	Branch	0.5	2.3	4
DECO-River Rouge (002A)	MI0001724	Wayne	4.3	22.0	4
Escanaba WWTP	MI0025381	Delta	3.3	15.0	8
Genesee County #3 WWTP	MI0022993	Genesee	0.7	1.8	7
Grand Rapids WWTP	MI0026069	Kent	2.7	11.0	8
Great Lakes Tissue	MI0002496	Cheboygan	30.0	110	6
Hemlock Semiconductor	MI0027375	Saginaw	1.0	2.6	7
Holly WWTP	MI0020184	Oakland	1.5	6.3	8
Ludington WWTP	MI0021334	Mason	3.4	18.0	4

TABLE 2-7: NPDES PERMITTED FACILITY LOW-LEVEL EFFLUENT MERCURY DATA (THRU 2003) WITH LESS THAN 10 QUANTIFIABLE DATA POINTS

FACILITY	PERMIT NUMBER	COUNTY	ARITHMETIC MEAN (ng/L)	PREDICTED EFFLUENT CONCENTRATION (ng/L)	N
Meadwestvaco-Escanaba Paper	MI0000027	Delta	6.7	19.0	6
Milford WWTP	MI0023604	Oakland	2.2	8.3	4
Portage Lake Water & Sewage Authority	MI0020061	Houghton	8.9	26.0	8
Romeo WWTP	MI0021679	Macomb	1.3	5.5	4
Trenton WWTP	MI0021164	Wayne	7.3	35.0	3
Ypsilanti Community Utilities Authority WWTP	MI0042676	Washtenaw	0.9	3.9	4

Estimated mercury releases to Michigan waterbodies (shown in **Table 2-8**) are based on the *2002-2003 Annual Wastewater Report* and *Toxics Release Inventory* and should be considered estimates only.

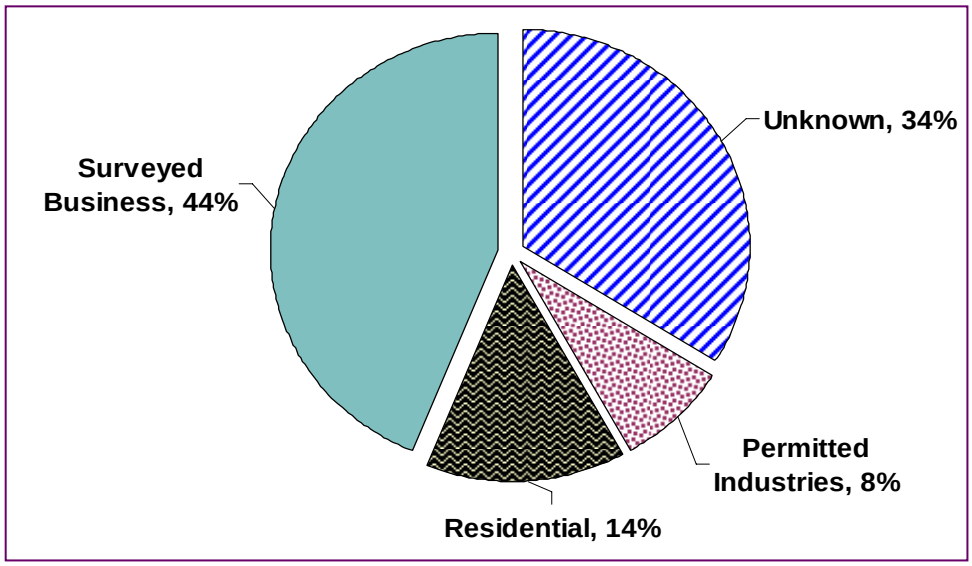
TABLE 2-8: MERCURY RELEASES FROM INDUSTRIAL/COMMERCIAL SOURCES TO MICHIGAN SURFACE WATERS

(2002-2003 Annual Wastewater Report and Toxics Release Inventory)

YEAR	HG RELEASED TO SURFACE WATERS ON-SITE (LBS)	HG RELEASED TO WWTP (LBS)	HG TRANSFERRED FOR OFF-SITE TREATMENT OR DISPOSAL (OTHER THAN WWTP)
2002	490	150	57

The following **Figure 2-7** presents mercury contribution estimates by source from a Minnesota WWTP facility (Western Lake Superior Sanitary District, 2002). The Minnesota facility estimates are included as an example because of their significant work on mercury source identification and reduction efforts.

FIGURE 2-7: WASTEWATER MERCURY SOURCES BY SECTOR IN MINNESOTA



2.3 CONCENTRATIONS AT SITES OF ENVIRONMENTAL CONTAMINATION

Releases of mercury from sites of environmental contamination are addressed by the state clean-up program (Part 201).[28] A Part 201 facility includes any area, place or property where a hazardous substance exists in excess of concentrations which satisfy the clean-up standards (clean-up standards are further discussed in **Chapter 3.3**). The process to address the exceedances of clean-up standards includes decisions to mitigate risks, including remediation by persons responsible for causing the contamination, due care for non-liable owners or operators, and disclosure of the general nature and extent of the release with any transfer of an interest in the property .

The sites of environmental contamination where mercury is a contaminant of concern are considered mercury legacy sites. Mercury releases may have occurred from historical manufacturing operations, waste disposal of products or byproducts containing mercury, and on-site laboratory facilities. Mercury releases may continue to leach to groundwater or surface water from historical manufacturing or disposal practices, or result from chemical or biological process involved in contaminant natural attenuation processes.

Sites where on-going releases of mercury are occurring to the groundwater or surface water are a program priority. Releases, and potential releases, resulting from contaminated groundwater venting to surface waters above WQS, require evaluation with specific sample collection and low level analysis techniques. The sensitivity of 'clean mercury' sample collection and low level analysis has provided significant information on mercury groundwater concentrations. **Table 2-9** provides a range of mercury groundwater concentrations (shown as ppm or parts per trillion [ppt]) found at specific types of sites where mercury is a known contaminant of concern.

TABLE 2-9: RANGE OF MERCURY GROUNDWATER CONTAMINATION

TYPE OF FACILITY	RANGE OF MERCURY GROUNDWATER CONCENTRATIONS
Cement kiln dust storage and disposal locations	200 to 400 ppt
Former manufactured gas plants	50 to 150 ppt
Former mercury cell chlor-alkali facilities	100 ppm to 3200 ppm
Iron blast furnace operations (iron slag)	100 ppt
Leather tanning facilities	40-60 ppt
Petroleum refinery	250-800 ppt
Scrap yards	300-500 ppt

Acronyms: ppm = parts per million; ppt = parts per trillion

The nature and extent of contamination has to be defined in order to estimate a release at a site of environmental contamination. The sample results from site investigations have shown groundwater mercury background concentrations to be widely variable depending upon the local lithology.[29] It is not uncommon for background groundwater concentrations to be below the 0.05 ppt detection level of the low level mercury analysis techniques.

Information on mercury releases is limited because the clean-up program provisions do not require a person to identify a site of contamination to the MDEQ. A person is allowed to undertake response activities to remediate the contamination without prior approval by the

[28] Part 201, Environmental Contamination of the NREPA.

[29] Background defined by R 299.5701(b) means the concentration or level of a hazardous substance which exists in the environment at or regionally proximate to a site that is not attributable to any release at or regionally proximate to the site.

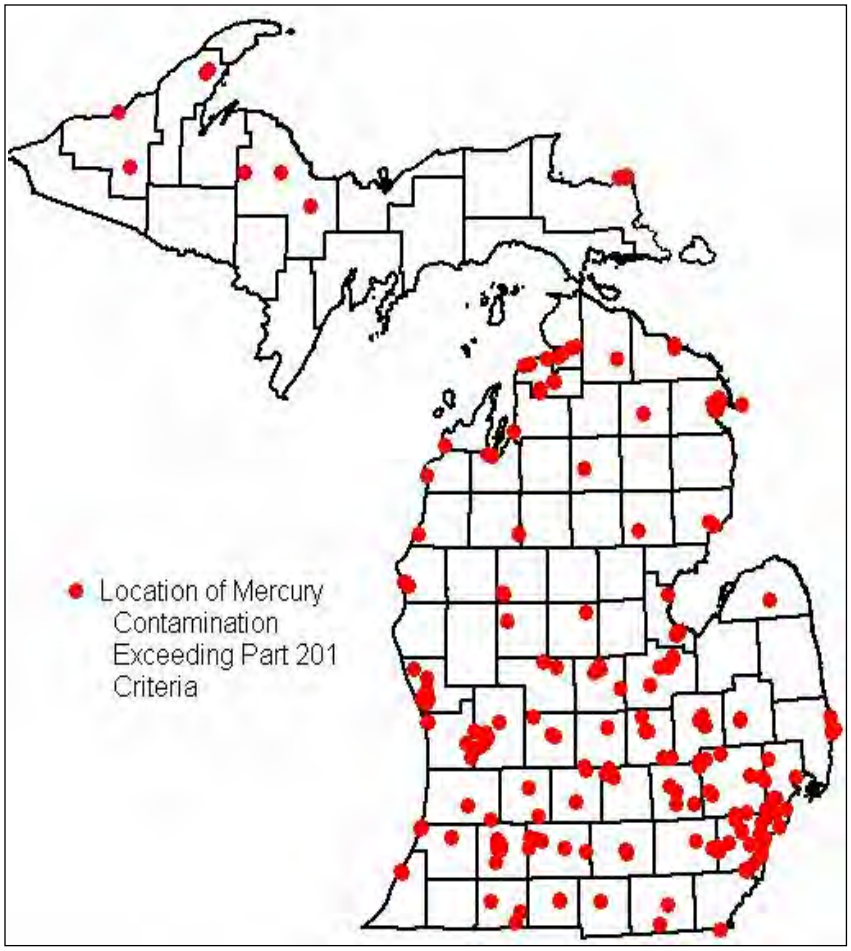
MDEQ. Information on mercury contamination is further limited by the fact that there is no standard requirement for investigation of a site of contamination that would identify the presence of mercury. Information is available from known Part 201 facilities and Baseline Environmental Assessments that indicates mercury releases from historical manufacturing operations are common and may represent a significant source of anthropogenic mercury releases.[30] **Table 2-10** provides information on historical manufacturing operations that are sources of anthropogenic mercury releases.

Estimating releases from mercury legacy sites is not possible from the current data available. Reporting requirements for sites of environmental contamination are very limited. There are approximately 3000 sites of contamination included on the Part 201 list of sites of environmental contamination, and the MDEQ has received 8000 Baseline Environmental Assessments for Part 201 sites. It is estimated there are more than 50,000 additional Part 201 sites that the MDEQ has no specific information about.

Site databases do not consistently indicate whether mercury has been identified as a contaminant of concern. Generally, the nature and extent of contamination is not adequately defined to allow an estimate of the mass of mercury remaining on site until specific clean-up plans are being developed.

Figure 2-8 maps the known sites of contamination where mercury releases have been identified to the MDEQ. A list of the known sites where mercury is a contaminant of concern is available in **Appendix H**.

FIGURE 2-8: KNOWN MERCURY SITES OF ENVIRONMENTAL CONTAMINATION



[30] Baseline Environmental Assessment defines the existing conditions and circumstances at a facility so that in the event of a subsequent release there is a means to distinguish the new release from the existing contamination.

TABLE 2-10: EXAMPLES OF SITES WITH ENVIRONMENTAL CONTAMINATION

SOURCES	EXAMPLE	LOCATION	DETAILS
ANTHROPOGENIC SOURCES			
Mercury Cell Chlor-Alkali	Wyandotte Chemical Facility (now BASF Corporation)	Wayne County	Historical operations using Hg(0) in manufacturing process resulted in releases of mercury to soils and groundwater. Mercury groundwater concentrations have required response actions to contain and prevent its migration to surface waters.
Cement Kiln Dust	Bay Harbor	Little Traverse Bay	The disposal of cement kiln dust from cement manufacturing in areas where it is below groundwater, or leaching to groundwater, results in elevated pH and releases of mercury to groundwater and surface waters.
	St. Mary's	Charlevoix	
	National Gypsum	Alpena	The erosion of waste to surface waters at National Gypsum has deposited the waste on the bottomlands.
Scrap Yard Operations			Mercury is generally associated with other site contaminants in the upper 6 inches of soil. Concentrations typically exceed direct contact criteria and approach criteria for volatilization to ambient or indoor air. Limited sampling has indicated there is potential for airborne concerns and there are frequent concerns with stormwater runoff.
Manufactured Gas Plants	Detroit Edison, CMS, and *SEMCO* have identified 70 former MPG facilities that have mercury releases.		The Gas Research Institute has identified a list of chemicals present in process residuals (coal tars) from manufactured gas plants which include mercury. Coal tars disposed below the water table, or leaching to the groundwater, result in releases to the groundwater and potentially surface waters.
Leather Tanning	Whitehall Leather	White Lake	Mercury from the tanning process is associated with disposal of tanning wastes. Mercury concentration in soils are an ongoing source of release to the groundwater that vents to White Lake.
	Cannelton Industries	Sault Ste Marie	Operation has resulted in releases from waste disposal into wetlands and St. Mary's River.
Iron Slag	McLouth Steel Trenton	Trenton	Iron slag used in iron blast furnace operation and disposed of in groundwater results in elevated pH levels and mercury releases.
Petroleum Refineries	Osceola Refinery	Grayling	Mercury from the petroleum refining process has resulted in releases to soil and groundwater.
Stampsands			Sediment investigations of disposal of the Stampsands in the groundwater and surface waters indicate releases of mercury.
Manufacturers with on-site laboratory			Mercury use in on-site laboratories has frequently been associated with soil contamination.
MERCURY RELEASES DISCOVERED WITH DEMOLITION OF MANUFACTURING OPERATIONS			
Manufacturing Operations	Hitachi Magnetics	Edmore	The site had known mercury releases in groundwater, and with the demolition of a portion of the facility, Hg(0) was visible. Approximately 2633 cubic yards of mercury-contaminated hazardous wastes and 4,586 gallons of liquid hazardous wastes, along with approximately 600 cubic yards of non-hazardous waste and demolition debris were removed to remediate the contamination.
Concrete	Hitachi Magnetics	Edmore	Concrete in contact with mercury is known to absorb it.
	BASF Riverview	Wayne County	

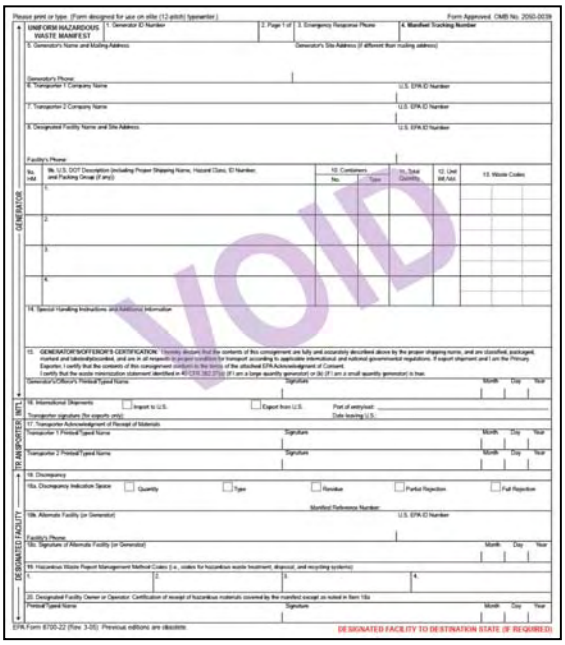
2.4 MERCURY IN WASTE

The MDEQ's Waste and Hazardous Materials Division (WHMD) regulates many different waste materials. The waste regulations are generally developed to prevent releases to the environment, with drinking water protection being the primary driver. Waste laws differ from many other environmental laws because the requirements for most generators are self implementing management standards. Laws targeting a specific media (i.e., air and water) are geared more toward permitting use of the resource. Therefore, the waste programs, in general, do not have specific detailed information for every regulated person. These program areas have differing levels of information related to mercury depending upon the level of information required to be submitted or reported.

2.4.1 HAZARDOUS WASTE

Mercury is a hazardous waste constituent regulated pursuant to Part 111 of the NREPA. Part 111 identifies and imposes standards on generators, transporters and treatment, storage and disposal facilities managing hazardous waste in Michigan. One of the key required items of hazardous waste transportation is a hazardous waste manifest (**Figure 2-9**) for every shipment of regulated hazardous waste.

FIGURE 2-9: HAZARDOUS WASTE MANIFEST



The hazardous waste manifests are required to be submitted to the MDEQ and the information is recorded in the Waste Data System (WDS) (formerly known as the Michigan Manifest Tracking System).[31] However, there are exemptions and exclusions from the manifest requirements.[32] Shippers of certain waste such as Hg(0), mercury from households, and mercury from small hazardous waste generators (known as conditionally exempt small quantity generators), for example, are not required to utilize a manifest for their mercury waste shipments. The manifest information, therefore, should not be viewed as a complete picture of hazardous waste shipments of mercury.

Part 111 identifies two categories of hazardous waste, listed hazardous waste and characteristic hazardous waste. Listed hazardous waste is identified by the process that produces the waste and characteristic hazardous waste is identified by generic properties. For the purpose of this report, the following tables contain information queried from the WDS database to determine the amount of mercury-containing hazardous waste produced in and/or shipped to Michigan from 2000 to 2006.

[31] On October 26, 2005, the WDS replaced the Michigan Manifest Tracking System. The WDS tracks activities at facilities regulated by the Solid Waste, Scrap Tire, Hazardous Waste, and Liquid Industrial Waste programs, and the Hazardous Materials and Transportation Act (Act 138). This program contains information on ownership and operation of the facility; the status of any required permits, licenses, registrations, or certifications; compliance status; authorized transporters; shipments of hazardous or liquid industrial waste (manifest); and user fees.

[32] The MDEQ's Hazardous Waste, Liquid Industrial Waste, and PCB Manifest Requirements are available at http://www.deq.state.mi.us/documents/deq-whm-hwp-new-uniform-manifest-information.pdf.

LISTED HAZARDOUS WASTE

Listed hazardous waste comes from the various processes that produce waste, such as discarded mercury-containing products (identified with a hazardous waste code of U151). A description of the various types of hazardous wastes that identify mercury as a basis for listing, along with their hazardous waste code is shown in **Table 2-11**.

TABLE 2-11: MERCURY-BASED HAZARDOUS WASTE

HAZARDOUS WASTE CODE	DESCRIPTION OF HAZARDOUS WASTE
K071	Brine purification muds from the mercury cell process in chlorine production, in which separately pre-purified brine is not used
K106	Wastewater treatment sludge from the mercury cell process in chlorine production
K175	Wastewater treatment sludge from the production of vinyl chloride monomer using mercuric chloride catalyst in an acetylene-based process
P065	Mercury fulminate
P092	Phenylmercury acetate
U151	Applies to Hg(0) when discarded as an unused commercial chemical product. The term commercial chemical product refers to a chemical substance which is manufactured or formulated for commercial or manufacturing use which consists of the commercially pure grade of the chemical, any technical grades of the chemical that are produced or marketed, and all formulations in which the chemical is the sole active ingredient.

The WDS database was queried by hazardous waste code to determine the amount of listed hazardous waste that was generated in or shipped to Michigan from 2000 to 2006. Information on any waste that was shipped to out-of state facilities was also queried. The results are shown according to the hazardous waste code. Note: Searches for K175 and P065 did not yield any shipments between 2000 and 2006.

U151: The WDS database reports that 10 lbs of U151 was transported into Michigan from an out-of-state generator from 2000 to 2005. In 2006, 14 lbs of U151 waste was shipped to out-of-state facilities. **Table 2-12** lists the U151 WDS Data that was generated in Michigan.

TABLE 2-12: U151 WDS DATA GENERATED IN MICHIGAN

YEAR	GALLONS	CUBIC YARDS	POUNDS
2000	3,158	30	3,685
2001	380	250	1,280
2002	247	320	897
2003	16	44	5,174
2004	212	218	1,008
2005	406	5	856
2006	56	80	109

K071: The WDS data indicate that from 2000 to 2005, K071 was not generated in Michigan. However, it appears that K071 was treated and managed at a commercial hazardous treatment facility in Michigan. In 2006, the WDS data indicates that approximately 8720 gallons, 180,036 cubic yards, and 1,050,627 lbs of K071 waste was transported to Michigan facilities.

K106: The WDS data indicate that K106 was not generated in Michigan between 2000 and 2006. However, it appears that K106 was treated and managed at commercial hazardous treatment facilities in Michigan. From 2000 to 2006, approximately 420 cubic yards and 39,480 lbs of K106 were transported to Michigan facilities from out-of-state. In 2006, 40 cubic yards of K106 waste was shipped to out-of-state facilities.

P092: The WDS data indicate that 30 gallons and 100 lbs of P092 were generated between 2000 and 2006. An additional 40 cubic yards and 112 lbs were generated out-of-state and transported to Michigan facilities.

CHARACTERISTIC HAZARDOUS WASTE

Part 111 defines a mercury toxicity characteristic hazardous waste as a waste that yields an extract that contains 0.02 milligram per liter (mg/L) of mercury, or greater, when a representative sample is subjected to the Toxicity Characteristic Leaching Procedure (TCLP), EPA Method 1311. This is the same test procedure found in the federal hazardous waste regulations. Hazardous waste exhibiting the characteristic of toxicity for mercury is given the hazardous waste code D009. The WDS was queried for all manifests of Michigan generators, except those licensed as hazardous waste treatment, storage or disposal facilities containing the waste code D009. These results are shown in **Table 2-13**.

TABLE 2-13: D009 WDS INFORMATION FOR MICHIGAN GENERATORS

YEAR	GALLONS	CUBIC YARDS	POUNDS
1996	18,011	453	1,992,670
1997	19,903	310	551,415
1998	98,654	592	685,527
1999	8,604	29	368,455
2000	12,594	778	138,858
2001	51,068	3,419	406,052
2002	19,429	8,362	196,698
2003	27,567	16,722	232,577
2004	43,933.29	8,870,952	1,240,627
2005	34,335	38,406	209,048

The same search was performed for shipments to Michigan originating out of state. **Table 2-14** shows the records of out-of-state generators shipping D009 hazardous waste into Michigan facilities for the years 2000 through 2005.

TABLE 2-14: D009 WDS INFORMATION FOR OUT-OF-STATE GENERATORS

YEAR	GALLONS	CUBIC YARDS	POUNDS
2000	10,687	1,237	181,864
2001	6,079	13,818	272,029
2002	13,027	380	204,822
2003	13,825	64,227	420,773
2004	41,958	25,199	402,484
2005	51,060	13,407	273,528

Flow Model for Universal Waste Type Materials: The universal waste regulations streamline collection requirements for certain hazardous wastes generated by a wide variety of generators and are indistinguishable, based on visual inspection, from material from exempted generators or from generators regulated under NREPA Part 111. Universal waste falls into the following categories: batteries, pesticides, mercury-containing equipment (e.g., thermostats, barometers, and manometers), electric lamps and consumer electronics. The rule is designed to

reduce hazardous waste in the municipal solid waste stream by making it easier for all universal waste handlers to collect these items and send them for recycling or proper disposal. There is no requirement for manifesting shipments of universal waste and because there are no tracking documents, the flow model will be used to estimate the quantities of these materials entering the waste stream (Minnesota Pollution Control Agency, 2001).

2.4.2 SOLID WASTE

The exact amount of mercury in the solid waste stream in Michigan is unknown. It has been estimated for Michigan's inventory that the mercury concentration of municipal solid waste is 0.0040 lbs of mercury per ton (Van Veizen et al., 2002) (see **Appendix H**). Michigan's solid waste regulations pursuant to Part 115 of the NREPA do not require testing of waste being managed at a solid waste processing or disposal facility. There are also no requirements for a manifest to accompany a load of solid waste to a disposal facility.

Households and conditionally-exempt small quantity generators landfill many sources of mercury, including batteries, fluorescent lights, mercury switches, and mercury thermometers. The actual amount of mercury disposed in Michigan solid waste landfills is unknown. In addition to mercury-containing waste disposed in landfills, Michigan's solid waste landfills may use alternatives to soil as a daily cover to bury the waste. These materials are currently limited to 2,000 ppm mercury. However, this number is under review by the MDEQ and is expected to be reduced.

LAND APPLICATION OF MERCURY-CONTAINING WASTES

Land application of solid waste for beneficial reuse as a soil amendment must meet background criteria of 0.13 ppb. By meeting background criteria the material may be designated inert per solid waste regulations and may be land applied for beneficial purposes. However, land applying wastes containing background mercury levels may not be protective of the groundwater and surface water (1.3 ng/L) exposure pathways depending on the leachability of the mercury in the waste. For example, NPDES surface water permits restrict the discharge of mercury. That mercury then is concentrated in industrial sludge. If an industry requests approval to land apply the sludge (e.g. paper mill sludge) for beneficial purposes they would have to meet background soil limits, however, these background limits may leach at levels higher than the 1.3 ng/L surface water limit. The MSWG recommends that limitations be placed on the use of the material to reduce environmental impacts to prevent transferring mercury from air to land to water.

MERCURY EMISSIONS FROM LANDFILLS

Landfills accept many sources of mercury, including batteries, fluorescent lights, switches, and thermometers. A study by Steven Lindberg and Price (1999) found that there are two primary pathways of mercury emissions from landfills. They are landfill gas from active and passive venting systems, as well as emissions from the surface of the landfill, through the cover, and emissions from the daily activities at a working area. An additional study, encompassing more landfills in Florida by Lindberg, et al, (2005) published in July 2005, found that the emissions contained more mercury than the original study had predicted.

In September 2005, the EPA released a "*Guidance for Evaluating Landfill Gas Emissions from Closed or Abandoned Landfills*." They found that mercury emissions from a landfill could be between a few hundred and several thousand ng/m^3. Coal-fired EGUs can produce emissions that are equivalent to the higher end of that spectrum, but the landfill emissions are a much smaller volume. The EPA found insufficient data to

adequately characterize the concentrations of mercury in landfill gas during National Emissions Standards for Hazardous Air Pollutants (NESHAP). The MACT for mercury from landfill flares is no emissions reductions because there are no alternatives.

2.4.3 MEDICAL WASTE

The medical waste program does not track mercury concentrations in medical waste. The Medical Waste Regulatory Act (Part 138, Medical Waste Regulatory Act, of the Michigan Public Health Code, 1978 PA 368, as amended) does not regulate Hg(0) as medical waste. The concentration of mercury in Michigan's medical waste is unknown.

2.4.4 LIQUID INDUSTRIAL WASTE

Part 121 of the NREPA regulates the transportation and management of liquid industrial waste in Michigan. These wastes are, generally, in liquid form and are not a regulated hazardous waste. Although Part 121 requires manifesting of shipments of liquid industrial waste, the MDEQ does not have the manifest information on a searchable database nor is there a code associated with mercury. Therefore, the amount of mercury in liquid industrial waste in Michigan is unknown.

2.5 MERCURY IN PRODUCTS

Due to its unusual properties, mercury has been used in literally thousands of industrial (see **Appendix I**), agricultural, medical, and household applications (also discussed in **Chapter 2.5.2**). Mercury is a unique toxic heavy metal that is liquid at room temperature, is a good conductor of electricity, and easily alloys with many metals such as gold, silver and tin. Because mercury volume expands uniformly with increasing temperature over the entire temperature range of its liquid state, uses of mercury and mercury compounds are substantial in measuring and control devices including products with switches (a "Mercury Use Tree" in **Appendix J** provides a detailed listing of mercury sources and mercury-added product usage).[33] Some of the most common mercury-containing components found within many products are switch controls (tilt, pressure, and float switches), relays, and electrical contactors. Mercury-free alternatives are available for most of these applications (discussed in **Chapter 2.5.2**). The following mercury switch information was obtained from the report "*An Investigation of Alternatives to Mercury Containing Products*," and includes the mercury content reported by manufacturers to the Interstate Mercury Education and Reduction Clearinghouse (IMERC) (Galligan et al., 2003).

TILT SWITCH: A tilt switch is used in hundreds of position monitoring/control products and applications. A mercury tilt switch is a small tube with electrical contacts at one end of the tube. As the tube lifts, the mercury collects at the lower end, providing a conductive path to complete the circuit. When the switch is tilted back, the circuit is broken. The mercury content in a tilt switch is from 400 mg to 71,000 mg per switch.

PRESSURE SWITCH: A pressure switch is used in hundreds of pressure monitoring/control products and applications converting pressure change into an electrical switching function. A mercury pressure switch typically uses a piston, diaphragm or bellows acting as the pressure sensor to actuate the mercury switch. The mercury content in a pressure switch ranges greater than 1,000 mg.

[33] Information on mercury-containing products is also available at: http://www.michigan.gov/deqmercuryp2.

FLOAT SWITCH: A float switch, found in thousands of varied products and applications, such as sump pumps are used for liquid monitoring and control in tanks, wells, chambers, drillings, and other containers. A mercury float switch is typically located in a buoyant float housing and is actuated based upon rising and falling liquid levels operating in the same manner at the mercury tilt switch. The mercury content in a float switch ranges greater than 1,000 mg per switch.

While approximately 60% of the overall annual mercury emissions (approximately 7,000 lbs/yr) released are from combustion sources (naturally occurring or re-emitted mercury in the materials combusted), the remaining 40% is released due to mercury purposefully added to various items, such as mercury-added products and the various activities associated with mercury-containing waste. This silvery, toxic metal, present in hundreds of consumer products from electrical equipment to cosmetics, can be released to the environment during the various stages of the product life cycle (production, transportation, manufacturing, use and disposal).

In May 2006, in response to interest expressed by the EPA in working with states to determine the next steps in addressing mercury-added products, the QSC launched discussions with supporting analysis to identify, recommend, and discuss a list of mercury-added products on which state and federal agencies could focus to reduce the use of mercury, through both voluntary and regulatory mechanisms. The analysis relies substantially on the research conducted for the "*2005 Compendium of Mercury States' Activities*" (discussed in **Chapter 5.4.1**) but also includes other identified sources important to the discussions. The QSC convened a workgroup with representatives from five states and the IMERC that established ranking criteria for targeting mercury products and sectors, selecting products and sectors based on these criteria, and recommend potential voluntary and regulatory actions for reducing and managing mercury-added products (QSC, 2006). Under the leadership of MDEQ, this effort resulted in the development of the *Mercury-Added Product White Paper*.[34]

RITUAL USE OF MERCURY

Mercury is also used culturally. There are many urban areas in the U.S. where religious supply stores, known as botanicas, sell a variety of herbal remedies and religious items containing mercury. Some people use mercury as part of folk remedies and religious practices to attract luck, love, or money; protect against evil; or speed the action of spells (picture from EPA, 2006c). These uses may pose health risks because mercury vapors [liberated indoors in the process] can cause health problems, such as damage to the nervous system (EPA, 2006c). In February 2005, a representative of the Mercury Poisoning Project, a private organization that provides the public with information on the dangers of being exposed to mercury, identified concerns related to the ritual use of mercury. The EPA Office of Inspector General was asked to evaluate EPA actions to address the problem. In the EPA (2006c) report "*EPA Is Properly Addressing the Risks of Using Mercury in Rituals*," EPA staff and the Mercury Poisoning Project representative agree that the ritual use of mercury poses a health risk. [35] Those who use mercury in folk remedies and religious practices, as well as others who live in buildings where such rituals are performed, may be exposed to mercury vapors. The MDEQ developed a bi-lingual brochure that addresses ritual uses.[36]

[34] This white paper is located on the ECOS website at http://www.ecos.org/files/2727_file_Mercury_Added_Product_White_Paper_formatted_final_with_MS_changes.pdf.
[35] This report is available at http://www.epa.gov/oigearth/reports/2006/20060831-2006-P-00031.pdf.
[36] MDEQ's brochure is at http://www.deq.state.mi.us/documents/deq-ead-p2-mercury-hispmerc3.pdf.

REDUCTIONS OF MERCURY USE IN PRODUCTS

Significant mercury use reductions have already been achieved. Mercury has historically been used in many products and industrial processes, although it has been phased-out considerably. Mercury was used in water-based latex paints manufactured before 1991 as a preservative for paint in storage and to prevent mildew after the paint had been applied. Mercury was also used in tilt and pressure switches in such products as "silent" wall switches, chest freezer lights, automobile hood and trunk lights, children's shoe lights, and steam iron and electric space heater safety shut-offs. Mercury switches were not installed in automobiles after 2003 and switches are currently being taken out of some cars at the "end of life" by automobile recyclers (see **Chapter 4.2.2**). Mercury was also historically used in U.S. manufactured fireworks and explosives, and U.S. pesticide registrations canceled by 1995 (old stocks may still exist). Some of the national notable mercury reduction achievements that have phased-out the use of mercury include:

- White goods, i.e., washing machines ceased using mercury switches in 1972.
- Mercury has been banned for use in latex paints since 1991.
- L.A. Gear's My Lil' Lights shoes that used a mercury switch to light up stopped using mercury in June 1994.
- The Mercury-Containing and Rechargeable Battery Management Act (Public Law 104-142) took effect on May 13, 1996. Title II specifically prohibits the sale of any alkaline-manganese (except for button cells containing up to 25 mg mercury) and zinc-carbon batteries that contain mercury that was "intentionally introduced" (as distinguished from mercury that may be incidentally present in other materials used to produce these batteries).
- Auto manufacturers voluntarily ceased using mercury switches in cars beginning with the 2003 model year.
- Mercury stopped being used in pesticides and fungicides in 1994.
- Chest freezers built in 2002 and beyond no longer contain mercury tilt switches to activate the freezer compartment light.
- Healthcare Without Harm - Mercury in Flight Awards in 2003 recognized the following pharmacies for voluntarily agreeing not to sell mercury-containing fever thermometers.

Albertson- American Drugs	Brooks Drugs	CVS
Eckerd	Kinney Drugs	K-mart
Meijer Stores/Pharmacies	Rite-Aid	Safety First
Target Stores	The First Years	Toys 'R' Us
Walgreen	Wal-Mart	

There have been P2 grants and other initiatives that have helped in the reduction of mercury use in schools (discussed in **Chapter 4.2.8**). For example, beginning in the 1960s and continuing through the 1980s synthetic gymnasium flooring and outdoor track surfaces contained mercury compounds as a catalyst in the polyurethane formulation and were installed in many schools throughout the country. These products have been manufactured by the 3M Corporation under the name of Tartan ® floors and Tartan® track, and by other manufacturers including American Biltrite Rubber Co. Inc., Robbins, Athletic Polymer Systems (APS), Crossfield Products (Dex-O-Tex), Mondo Rubber, Pitzer Inc. and Selby Battersby & Company. The 3M Tartan Brand floor covering is a solid, rubber-like polymer floor covering developed in the 1960's and promoted as a substitute for and improvement over wood flooring in gymnasiums and as a durable running surface for both indoor and outdoor track & field facilities. According to 3M, mercury was used as a catalyst when mixing the polymer to form the floor covering resulting in a finished product typically containing 0.1% to 0.2% mercury. Although industry-wide data have not been collected, estimates from just one manufacturer (APS) claim that they have installed over 25 million lbs of polyurethane

flooring product over the past 40 years. The surfaces give off Hg(0) vapor when the top surface of the floor is damaged or during activities associated with removal of the mercury-containing material.

The MDCH and the Agency for Toxic Substances and Disease Registry (ATSDR) have been conducting mercury floor investigations in Michigan and other states to identify the controlling factors of mercury vapor emissions from synthetic gym floors and to develop procedures for safe removal of the damaged flooring and appropriate disposal requirements (discussed in **Chapter 4.2.8**). Preliminary screening by MDCH and county health agencies have found floors that emit unacceptable levels of vapor into the breathing zone of gyms.

Legislation has also reduced mercury use in schools and other applications (like fever thermometers, thermostats, and certain medical devices). These types of legislations are discussed further in **Chapter 3.7**.

2.5.1 ESSENTIAL USES OF MERCURY IN PRODUCTS

Over the last several decades, mercury's use in products, devices, applications and chemical compounds have purposely been phased-out of most applications and the small remaining list of those uses still considered "essential" continues to decline. Cost-effective, mercury-free alternatives are constantly being discovered and promoted throughout all sectors of business, industry, academia and institutions (see **Chapter 2.5.2**). A few items still considered essential in some sectors include:

- mercury dental amalgam for limited applications (contains ~50% mercury [ATSDR]; preferred by dentists for restorative use on load bearing, grinding surfaces),
- fluorescent lamps including compact fluorescent lamps (or CFLs as shown on the right),[37]
- a few rare pieces of scientific and/or physics equipment (i.e. atomic mercury magnetometer).

Even in applications deemed essential however, manufacturers are being challenged to find mercury-free alternatives or, at a minimum, to use the lowest mercury content possible to perform a given function.

Trace amounts of mercury may also be found in some stains, dyes, reagents, fixatives and vaccines. The problem of knowing whether such chemicals contain mercury often requires laboratory testing and is compounded by the fact that Material Safety Data Sheet requirements do not require complete disclosure of ingredients when they comprise less than 1% of a given formula. In addition, small amounts of mercury may be present as a result of processes used in the manufacture of caustics. Mercury-cell chlor-alkali production (a process that uses mercury in electrolysis of salts to produce hydrogen chloride and sodium hydroxide, chlorine, caustic soda, bleach, and other products), can result in small amounts of mercury in cleaning products as well as the products already listed above.[38] An alternative mercury-free production technology is available and gradually the chlor-alkali industry is shifting toward this newer 'reverse osmosis' mercury-free technology.

[37] The MDEQ's *Bright Idea* brochure on CFLs is available at http://www.michigan.gov/deqp2initiatives. The MDCH's CFL link is at http://www.michigan.gov/mdch/0,1607,7-132-2945_5105-13050--,00.html.

[38] Information on cleaning products is at http://www.michigan.gov/deq/0,1607,7-135-3307_29693_4175-11756--,00.html

Other devices that presently contain mercury, such as button cell batteries[39] and high intensity discharge (HID) vehicle headlights, have recently engineered totally mercury-free manufacturing processes and the industry is quickly moving in this direction. Ten years ago mercury-free button cells and lamps were not thought possible. As mercury use declines in fluorescent and HID lamp manufacture, perhaps soon mercury use can be phased out all together from this sector. Other long lived, energy efficient, mercury-free substitute lighting, such as light emitting diodes (LED's), are also expanding market share and showing signs of promise for some lighting applications.

Finally, there are some national and international scientific standard setting organizations that still require mercury-containing measuring devices to be used in various testing protocols. For instance, the National Institute of Science and Technology recently disclosed that there were 839 specific applications that called for the use of mercury thermometers to calibrate certain equipment (see **Chapter 3.5**). Other similar requirement may still be present in Federal Drug Administration standards, Standard Methods, and other testing performed by the pharmaceutical industry. The QSC has taken special interest in these uses and are currently challenging these scientific standard setting organizations to find and promote mercury-free alternatives whenever possible. The National Institute of Science and Technology and the American Society for Testing and Materials (ASTM) have responded favorably, however time and resources are still needed to expedite this change.

2.5.2 MERCURY-FREE PRODUCT ALTERNATIVES

Over the past several decades, the MDEQ has implemented a variety of methods to prevent or eliminate the use and release of mercury emissions. Primary efforts have been through regulations such as permits, enforcement, and legislation prohibiting the sale or use of certain mercury-containing products, and aggressive efforts to encourage voluntary reductions through P2 in the use of mercury-containing products. To date, the most effective P2 technique has been the replacement of mercury-containing devices or products with mercury-free alternatives (see **Chapter 4**).

Cost-effective, mercury-free alternatives are continually being discovered and promoted throughout all sectors of business, industry, academia and institutions. The MDEQ and the National Wildlife Federation (NWF) have worked to educate and provide concerned citizens with the information and tools needed to make informed decisions on ways to protect themselves and their environment from the risk of mercury exposure. In 2002, the NWF created the "*Mercury Products Guide: The Hidden Dangers of Mercury, A Resource Guide for Procurement Officers and Consumers about Mercury in Products and their Alternatives*" to assist the general public and procurement officers about the types of products that contain mercury and the alternatives available.

As stated previously, mercury has been used in literally thousands of industrial, agricultural, medical, and household applications due to its unusual properties. Therefore, it is important to realize that even though a product does not appear to contain mercury in its design, it may use a mercury-added component to perform a function (e.g. uses a battery, lights up when opened, etc.). Common products that may contain mercury-added components include:

- Gauges (used for measurements);
- Thermometers or thermostats (temperature/climate control devices);

[39] As stated in the QSC's Mercury-Added Product White Paper (2006), U.S. battery manufacturers have all voluntarily agreed to stop using (intentionally-added) mercury in button cell batteries by 2011.

- Switches used for on/off and/or safety mechanisms, fluid level control, etc. (tilt switches, float switches, pressure switches, flow meters, etc.);
- Flame sensors (any ignition source with a standing or spark ignition pilot light contains a mercury flame sensor); and
- Personal care products, household cleaners, and disinfectants (may contain mercury as a preservative or disinfectant);

Throughout the MSWG strategy, information has been provided discussing the management of mercury-added products that include mercury-free product alternatives or alternatives that use the lowest mercury content possible to function. In **Appendix K**, there are five tables that list the various types of products and/or chemicals that *may* contain mercury and available alternatives (if known). These tables are broken down into the following categories:

- **Table K-1** provides information on general types of consumer products purchased (appliances, batteries, lamps, household cleaners, novelties, etc.),
- **Table K-2** lists those types of products that would be generally found in a building, such as a home, business, school, etc.,
- **Table K-3** contains additional mercury-containing and other hazardous products that may be found in a school classroom,
- **Table K-4** contains information on devices, products and chemicals that may be utilized in the medical profession (including labs), and
- **Table K-5** shows the types of devices that may contain mercury that can be found in motorized vehicles (cars, boats, etc.).

Mercury alternative information provided in these tables were gathered from various sources that included the NWF (2002), Galligan et al. (2003), and other environmental agencies (MDEQ, EPA, other states, etc.): The following is a listing of websites that contain mercury alternative information [40]

- http://www.michigan.gov/deqmercuryp2
- http://www.deq.state.mi.us/documents/deq-ead-p2-mercury-consumer.doc,
- http://www.deq.state.mi.us/documents/deq-ead-p2-mercury-healthpr.doc,
- http://www.iatp.org/iatp/publications.cfm?accountID=421&refID=97327,
- http://www.epa.state.il.us/p2/green-schools/mercury-free-alternatives-for-schools.pdf,
- http://www.informinc.org/fsmercalts.pdf,
- http://www.mercuryinschools.uwex.edu/community/index.htm,
- http://www.p2pays.org/ref/26/25928.pdf,
- http://www.state.nj.us/dep/dshw/lrm/mercury_brochure.pdf,
- http://www.dec.ny.gov/docs/permits_ej_operations_pdf/merchosp.pdf,
- http://www.epa.gov/region5/air/mercury/appliancereport.html,
- http://www.epa.gov/glnpo/bnsdocs/hgsbook/index.html,
- http://www.purdue.edu/envirosoft/mercury/src/alternat.htm,
- http://www.hercenter.org/hazmat/mercury.cfm,
- http://www.michigan.gov/deq/0,1607,7-135-3307_29693_4175-11695--,00.html,
- http://www.epa.gov/region5/air/mercury/nwindianareport3-17-04.pdf, and
- http://www.premierinc.com/quality-safety/tools-services/safety/topics/mercury/premier_products.jsp

It is important to note that the lists contained in **Appendix K** is not an exhaustive list

[40] DISCLAIMER: These websites are not listed in any particular order and the MSWG does not take responsibility for the accuracy of the information. The information gathered was not validated and is being provided for informational purposes only.

and that some products listed may not contain mercury. To be certain, it is best to check with the manufacturer on a specific model to determine if it contains mercury and if a mercury-free alternative is available.

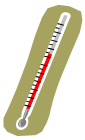
2.6 ELEMENTAL MERCURY [HG(0)]SPILLS

Currently, there are various agencies and other sources that can be contacted regarding Hg(0) spills and Hg(0) spill clean-up advice. For a "large" Hg(0) spill equal to or exceeding 1 lb (more than 2 tablespoons), it is required to be reported to specific agencies under federal regulations (see **Chapter 2.6.2**). But for "small" Hg(0) spills of less than a pound (the approximate equivalent of up to 2 tablespoons), there have historically been no reporting requirements at either the state or national level. Therefore, there is reason to expect that most small spills do not come to the attention of professional responders. Information on individuals that would be contacted regarding a mercury spill is presented in **Chapter 2.6.1**. However, beginning in 2006, mercury was added to the "mandatory reporting list" of the federal ATSDR Hazardous Substances Emergency Events Surveillance (HSEES) tracking system (discussed in **Chapter 2.6.2**). This means that **any** acute release of mercury is now required to be reported in HSEES, such as if a thermometer breaks, as well as other releases that involve some kind of response (i.e. clean-up contractor, MDEQ/EPA involvement, etc.). Under this new requirement, the number of mercury spills reported will increase. Michigan's participation in HSEES is called MI-HSEES and is discussed in **Chapter 2.6.1**.

For mercury spill clean-up information (both small and large) there are a variety of sources that offer guidance (see **Chapter 2.6.3**). However, sometimes the advice among these sources is inconsistent and may be conflicting. In addition, information is not always available on final clean-up costs for mercury spills since most data on incidents are fragmented, piecemeal, or anecdotal, and no single comprehensive tracking database exists. A collaborative attempt was made for a short period of time to collect this type of data by MDEQ and MDCH while mercury legislation was being developed for schools, however, lack of staff resources did not allow for continued monitoring and reporting.[41]

The following chapters discuss small and large Hg(0) spills that have occurred in Michigan, along with information on mercury spill clean-up.

2.6.1 SMALL HG(0) SPILLS



The typical small Hg(0) spill is from a mercury thermometer resulting between 0.5 to 1.5 g of mercury released. In their 2002 "*Behavior Risk Factor Survey*," the MDCH included two questions regarding mercury thermometers: 1) Do you have mercury thermometers in your home?, and 2) Do any children (under 18 years of age) in your house handle this thermometer? The report summarized the responses as:

> "An estimated 37.4% of Michigan adults reported that they had mercury thermometers at home. The prevalence of having a mercury thermometer increased with age and was higher with Caucasians (39.4%) than African Americans (24.3%). Among adults in households with children under the age 18, the estimated prevalence of mercury thermometers in the home was 36% and again was higher among Caucasians than African Americans (37.5% vs. 26.3%). Adults who had not graduated from high school (23.1%) were less likely to have a mercury thermometer than those with any college education (some college, 38.3%; college graduate, 42.4%), as were adults at the lowest (27.5%) compared with the highest income level (40.7%). In households with children, 10.9% of adults said their children handled the thermometers."

[41] Mercury spill information is available at http://www.michigan.gov/deq/0,1607,7-135-3307_29693_4175-11690--,00.html and http://www.michigan.gov/deq/0,1607,7-135-3307_29693_4175---,00.html.

Mercury responders concur that thermometers are by far the most frequent source of small mercury spills that comes to their attention. A distant second is a grouping of sphygmomanometers (blood pressure measuring devices), furnace thermostats, and a variety of mercury switches. Free flowing Hg(0) found in jars or cans are less common. The MSWG recommends that insurance companies should be educated on the hazards of mercury in the home and challenge them to offer incentives such as discounts on premiums for mercury-free homes with an emphasis on mercury thermometers and thermostats.

In industrial and commercial settings such as laboratories associated with a business, gauges and other monitoring devices are common sources of mercury spills. EPA initiated investigations of mercury spills associated with natural gas regulators in 2000 for the two major utilities in Michigan. This effort assisted in identifying many previously unknown historic spills and gave utilities incentive to revise their handling of mercury bearing regulators to prevent spills and contamination of homes.[42]

Those who are in a position to hear about a small Hg(0) spill are the two Michigan Poison Control Centers, MDEQ's Pollution Emergency Alerting System (PEAS), local health agencies, and the MDCH. The following are brief descriptions of these agencies who may be contacted regarding a mercury spill and the information they have received:

MICHIGAN POISON CONTROL CENTERS

The two regional poison control centers for Michigan are located at the Children's Hospital of Michigan in Detroit and the DeVos Children's Hospital in Grand Rapids.[43] As reported mercury spill statistics post-2001 continue to decline, staff of Michigan's poison control centers attribute the drop in mercury spill incidents to up scaled public education/outreach efforts coupled with the effects of P.A. 578 of 2002 (discussed in **Chapter 3.6.2**), which bans the sale of mercury thermometers in Michigan (Smolinske, 2005). **Table 2-15** shows the 5262 reports of small mercury spills since 2000 (2004 data is not included) with an estimated release of 11.6 lbs of mercury.[44]

TABLE 2-15: REPORTED MERCURY SPILLS TO MICHIGAN'S POISON CONTROL CENTERS

YEAR	NUMBER OF SPILLS*
2000	767
2001	1,350
2002	1,261
2003	774
2004	Info not accessible at this time
2005	697
2006	413

*As reported by Michigan's Poison Control Centers, the Detroit Medical Center, and DeVos Children's Hospital (Spectrum Health) (MDEQ, 2005)

POLLUTION EMERGENCY ALERTING SYSTEM (PEAS)

The MDEQ's PEAS has been in operation since 1975 and is used to report environmental pollution emergencies affecting air, land, and water (see **Appendix L** for

[42] For EPA information on spills go to http://www.epa.gov/epaoswer/hazwaste/mercury/faq/spills.htm.
[43] The emergency phone number for the two regional Poison Control Centers is 800-222-1222. On-line poison control listing is available at http://www.aapcc.org/states/mi.htm.
[44] To estimate the amount of mercury spilled, it was assumed that all the spills were from a thermometer containing at least 1 g each of mercury.

the PEAS mercury response spill protocol).[45] There are 24-hour toll-free numbers for calls originating both in and outside of the state of Michigan.[46] Between 8 a.m. and 5 p.m. on normal working days (Monday-Friday) the operators give callers the option of contacting the appropriate MDEQ district office serving the area where an incident has occurred, or the operators will take the information and dispatch the calls to the district offices for the caller. During non-business hours (after 5 p.m., holidays and weekends), calls are referred to a MDEQ employee who is on-call for the PEAS. That individual completes a Report of Incident and determines whether immediate referral is necessary or if the information can be referred during normal business hours. Calls are directed to MDEQ staff or other agencies depending on the type of situation. The nature of MDEQ staff response is generally to provide technical advice to first responders on actions they can take to minimize environmental damage. Since 1996, there have been a total of 109 mercury spills reported to the PEAS amounting to over 168 lbs of Hg(0) released to Michigan's environment. Of those 109 spills, 35 instances involved Hg(0) from a broken thermometer. **Table 2-16** lists the PEAS log of mercury spill calls.

TABLE 2-16: PEAS PHONE LOG OF MERCURY SPILLS SINCE 1996

***BOLD INDICATES A RELEASE ABOVE THE REPORTABLE QUANTITY**

INCIDENT DATE	AMOUNT OF MERCURY (OZ)	MERCURY SOURCE	LOCATION
8/05/96	**113**	**THERMOMETER**	**UNKNOWN**
12/02/96	4	Unknown	Floor
6/17/97	**32**	**ELEMENTAL**	**WINDOW SILL**
4/14/98	**80**	**ELEMENTAL**	**AIR PRESSURE VACUUM LINE**
5/31/98	Unknown	Transformer Pole	Grass
12/26/98	<1	Thermometer	Sink
12/29/98	<1	Thermometer	Unknown
4/07/99	1	Barometer	Plastic Bags
4/19/99	<1	Thermometer	Bathroom Drain
6/08/99	**50**	**ELEMENTAL**	**PARKING LOT**
6/09/99	**56**	**CLOCK**	**UNKNOWN**
8/26/99	4	Unknown	Unknown
1/11/00	<1	Unknown	Toilet
4/30/00	<1	Thermometer	Ground
6/13/00	**226**	**ELEMENTAL**	**GROUND**
8/18/00	<1	Unknown	Unknown
8/20/00	1	Thermometer	Unknown
9/16/00	Unknown	Elemental	Basement
9/17/00	**28**	**ELEMENTAL**	**KITCHEN FLOOR**
9/28/00	Unknown	Unknown	Unknown
11/20/00	**16**	**POWER HOUSE**	**INSIDE**
1/09/01	<1	Thermometer	Unknown
1/23/01	Unknown	Elemental	Storage Area
1/27/01	<1	Thermometer	Carpet
1/29/01	<1	Thermometer	Carpet
2/05/01	<1	Thermometer	Floor
3/07/01	1	Instrument	Ground
3/13/01	<1	Thermometer	Pan

[45] See the Spill/Release Reporting and Emergency Planning websites under http://www.michigan.gov/deq for additional spill/release reporting and prevention information.

[46] The phone number for calls originating in-state is 1-800-292-4706; the number to be used for calls originating out-state is 517-373-7660.

TABLE 2-16: PEAS PHONE LOG OF MERCURY SPILLS SINCE 1996

***BOLD INDICATES A RELEASE ABOVE THE REPORTABLE QUANTITY**

INCIDENT DATE	AMOUNT OF MERCURY (OZ)	MERCURY SOURCE	LOCATION
4/30/01	**226**	**WATER METERING DEVICE**	**FLOOR**
5/18/01	2.5	Elemental	Science Lab
5/31/01	Unknown	Unknown	Inside
6/25/01	<1	Thermometer	Unknown
11/02/01	<1	Thermometer	Unknown
12/01/01	**16**	**SPHYGMOMANOMETER**	**UNKNOWN**
3/01/02	<1	Thermometer	Garage
4/03/02	10	Elemental	Delivery Box
4/03/02	12	Package	Asphalt
4/25/02	**226**	**ELEMENTAL**	**PARKING LOT**
5/21/02	**176**	**CHART RECORDER**	**CEMENT**
5/22/02	14	Instrument	Rock Floor
5/22/02	<1	Thermostat	Inside
6/24/02	**113**	**ELEMENTAL**	**DRIVEWAY**
8/01/02	<1	Thermometer	Countertop
8/03/02	<1	Thermometer	Sink
8/24/02	<1	Thermometer	Home
8/26/02	Unknown	Elemental	Pickup Truck
10/09/02	**47**	**THERMOMETER**	**TRASH CAN**
10/10/02	Unknown	Sphygmomanometer	Inside
10/21/02	<1	Furnace	Basement
11/07/02	**47**	**MERCURY NITRATE**	**DRAIN**
11/09/02	**48**	**ELEMENTAL**	**PARKING LOT**
6/04/03	Unknown	Elemental	Building
6/19/03	2	Elemental	Sidewalk
6/19/03	2	Elemental	Unknown
9/21/03	1	Thermometer	Cupboard
11/30/03	Unknown	Asphalt	Wetlands
12/09/03	<1	Thermometer	Inside
11/24/04	<1	Thermostat	Inside
2/15/04	Unknown	Elemental	Lumber
3/12/04	**118**	**FLUORESCENT TUBES**	**TRASH CAN**
5/07/04	**226**	**ELEMENTAL**	**PARKING LOT**
6/09/04	Unknown	Elemental	Inside
6/11/04	**170**	**DRAIN LINE**	**BASEMENT**
7/06/04	<1	Thermostat	Floor
7/25/04	<1	Thermometer	Car
7/28/04	Unknown	Elemental	Water System
8/04/04	Unknown	Unknown	Unknown
8/11/04	3.5	Sphygmomanometer	Floor
10/11/04	Unknown	Elemental	Cabinet
12/06/04	Unknown	Elemental	Garage
2/18/05	<1	Thermometer	Inside
3/15/05	4	Unknown	Driveway
3/15/05	3	Unknown	Unknown
4/06/05	Unknown	Unknown	Unknown
4/15/05	2.5	Unknown	Bus
4/30/05	**226**	**ELEMENTAL**	**BASEMENT**
7/04/05	<1	Thermostat	Porch
7/23/05	<1	Thermometer	Pool

TABLE 2-16: PEAS PHONE LOG OF MERCURY SPILLS SINCE 1996
***BOLD INDICATES A RELEASE ABOVE THE REPORTABLE QUANTITY**

INCIDENT DATE	AMOUNT OF MERCURY (OZ)	MERCURY SOURCE	LOCATION
8/10/05	**160**	**INSTRUMENT**	**GROUND**
8/10/05	<1	Elemental	Car
8/29/05	<1	Thermometer	Sink
9/14/05	<1	Thermometer	Inside
9/23/05	14	Elemental	Inside
11/01/05	<1	Thermostat	Street
11/11/05	**16**	**BAROMETER**	**INSIDE**
12/27/05	8	Elemental	Roadside
2/03/06	<1	Thermometer	Unknown
2/03/06	14	Thermometer	Unknown
2/13/06	<1	Thermometer	Kitchen Floor
2/18/06	<1	Thermometer	Bathroom and Bedroom
3/10/06	Unknown	Elemental	Washers
4/17/06	2.5	Thermostat	Fish Tank
5/10/06	**113**	**ELEMENTAL**	**LAB**
6/5/06	About 8	Elemental	Parking Lot
6/23/06	**16**	**Elemental**	**Basement work bench**
7/8/06	**16**	**Elemental**	**Floor**
8/26/06	<1	Thermometer	Unknown
9/28/06	Unknown	Elemental	Floor
10/10/06	**UNKNOWN**	**UNKNOWN**	**WATER SYSTEM**
1/8/07	Unknown	Necklace	School
1/25/07	**16**	**ELEMENTAL**	**ZOO**
3/4/07	<1	Thermometer	Home
3/23/07	**LARGE AMOUNT**	**UNKNOWN**	**PARKING LOT TO STORM DRAIN**
3/28/07	**UNKNOWN**	**ELEMENTAL**	**USED IN INDUSTRY PROCESS**
4/3/07	1	Elemental	Property
4/30/07	6	Unknown	Unknown
5/3/07	<1	Thermometer	Unknown
5/8/07	**UNKNOWN**	**HG-BASED PESTICIDES**	**GOLF COURSE**
5/11/07	<1	Thermometer	Vehicle

MICHIGAN DEPARTMENT OF COMMUNITY HEALTH (MDCH)

In Michigan, a number of laws and regulations require reporting of hazardous substance releases (including mercury spills) to state and federal agencies by companies, transportation carriers, HazMat[47] first responders, and others. In 2004, the MDCH signed a cooperative agreement with the ATSDR to participate in the federal HSEES tracking system (discussed further in **Chapter 2.6.2**). Currently, fourteen other state health departments have cooperative agreements under the HSEES program: Colorado, Florida, Iowa, Louisiana, Minnesota, Missouri, New Jersey, New York, North Carolina, Oregon, Texas, Utah, Washington, and Wisconsin. As a HSEES participant, each state enters data into a web-based application that enables ATSDR to instantly access data for analysis. All states use the same protocol to collect, analyze and disseminate data on acute chemical releases and related adverse health effects, and conduct interventions to mitigate the impacts of releases on environmental and human health.

[47] HazMat requirement information can be found under the Hazardous Materials Transportation Act at http://www4.law.cornell.edu/uscode/html/uscode49/usc_sec_49_00005102----000-.html

The MDCH first received funding for the Michigan HSEES program, called MI-HSEES, in October 2004, with data collection beginning in January 2005.[48] Various sources are used to identify and obtain information about HSEES-eligible events in Michigan. These include reports that are maintained by the MDEQ (i.e., PEAS), MDA, Michigan Department of Labor and Economic Growth (DLEG), Michigan State Police, the State Fire Marshal's Office, and information from the media, along with data that is utilized by the federal Department of Transportation and the National Response Center (NRC) (information on the NRC is discussed in **Chapter 2.6.2**).

The MDCH released its first year annual progress report in September 2006.[49] As stated in the report, the data show that the MI-HSEES system is useful for characterizing the variety of hazardous substances releases in Michigan and identifying useful follow-up public health actions. However, the report also noted several concerns due to the probability that the data undercounts all hazardous substances emergency release events in Michigan for a number of reasons. First, the MI-HSEES network of reporting sources was not fully established until later in 2005; and second, a number of reporting agencies indicated their belief that responsible parties are not always reporting release events that are required under various laws and MI-HSEES cannot identify such events unless they are identified in an alternate source (e.g., the media).

Table 2-17 gives a current overview of the 45 Michigan mercury-related releases that have been reported to MI-HSEES since data collection began (January 2005). It is estimated that these 45 incidents amounted to approximately 70 lbs of mercury being released into the environment. One noted area of interest found in the MI-HSEES data relates to the Michigan law that mandates schools to be mercury-free by December 2004 (see **Chapter 3.6.1**). As shown in **Table 2-17**, there were a total of 20 events of mercury spills in schools with the majority resulting in school evacuations and/or school closures. At least half (10) of those events were from mercury or mercury-containing items found at the school, six involved children bringing mercury-containing items to school and four events were unknown or not stated. The MDCH, in response to these findings, is collaborating with the MDEQ and the Michigan Department of Education (MDE) in conducting a survey and providing technical advice to assist schools in meeting compliance with the law. This information, along with other mercury in schools information is discussed further in **Chapter 4.2.8**.

[48] Complete information on the MI-HSEES program can be found at http://www.michigan.gov/mdch-toxics.
[49] MI-HSEES 2005 report is at http://www.michigan.gov/documents/mdch/HSEESAnnual_Report_174705_7.pdf.

TABLE 2-17: MERCURY RELEASES REPORTED TO MI-HSEES SINCE 2005

DATE OF EVENT (ACTION END DATE)	TYPE AND AMOUNT OF MERCURY RELEASED	DID EVENT MEET HSEES CRITERIA	WHO NOTIFIED MI-HSEES	LOCATION OF EVENT (TYPE OF AREA)	COUNTY	IMPACTED AREA OF RELEASE	TYPE OF FACILITIES WITHIN 1/4 MILE OF EVENT	SYNOPSIS
2/28/05 (3/1/05)	Threatened release of 30 lbs	Y	Other Program within MDCH	Home (Residential)	Genesee	Immediate area and within 10 feet	Residence, Day Care, Business, Recreational Area	Homeowner called EPA to report that he had mustard gas, mercury, and several other unknown chemicals (one of which burned his skin when touched) in his house. Later said there was no mercury. His father, no longer living, brought these chemicals home from work (Dow Chemical). FBI was called and arranged with Dow's HazMat team to pick-up, transport, and dispose of these chemicals.
3/15/05 (3/16/05)	Spill of 4 ounces (by volume)	Y	MDEQ	Home (Residential)	Wayne	Immediate area and within 10 feet	Residence, Business	Realtor found an 8 oz jar on the driveway by the corner of a foreclosed house. The top was off and there was a 2 inch puddle containing about 4 oz of mercury. Fire department responded and called Inland waters to clean-up. They taped the driveway, vacuumed the mercury and heated the area.
4/30/05	Spill of 16 ounces (by volume)	Y	Emergency Government / Emergency Services	Home (Residential)	Wayne	Immediate area and within 10 feet	Residence, Hospital, Nursing Home, Business, Recreational Area	Contractor renovating abandoned house knocked pint size jar of mercury over about a week prior. He tried to clean it up and was brought to the hospital to be treated for contamination. Spoke to Detroit Health Department, stated there is ongoing clean-up as still elevated levels in the house. House remains vacant.
5/2/05 (5/4/05)	Spill of 7 lbs	Y	Emergency Government / Emergency Services	Saginaw Marine Terminal (Industrial)	Bay	Immediate area and within 10 feet	Residence, Business	Caller indicated children entered a defunct business warehouse facility and vandalism occurred causing the release of materials. Inland waters came and cleaned up within 24 hours. Present in the warehouse was 300+ lbs of mercury and 34 gal of PCB (polychlorinated biphenyls) oil that was not spilled.
5/2/05 (5/5/05)	Fire released unknown amount into environment	Y	Media	Home (Commercial)	Bay	Building and up to 100 feet	Residence, Business	18-year old youth was injured and his home was destroyed by fire due to experimenting with his chemistry set. Four people were evacuated. Youth appeared to suffer from chemical burns and was taken to local hospital's burn unit and was listed in critical condition. His left hand was amputated. Officials believe mercury and lead were involved. Blood tests are being conducted on the following personnel that assisted at the scene: Bangor Township firefighters (19), Bay City firefighters (7), Michigan State Police (4), and Bay County Sheriff's Deputies (2).

TABLE 2-17: MERCURY RELEASES REPORTED TO MI-HSEES SINCE 2005

DATE OF EVENT (ACTION END DATE)	TYPE AND AMOUNT OF MERCURY RELEASED	DID EVENT MEET HSEES CRITERIA	WHO NOTIFIED MI-HSEES	LOCATION OF EVENT (TYPE OF AREA)	COUNTY	IMPACTED AREA OF RELEASE	TYPE OF FACILITIES WITHIN 1/4 MILE OF EVENT	SYNOPSIS
5/2/05 (5/24/05)	Spill of 3 ounces (by volume)	Y	Emergency Government / Emergency Services	Battle Creek Public Schools (Residential)	Calhoun	Section of Building and up to 50 feet (Building restricted)	Residence, School, Day Care, Business, Recreational Area	Students found mercury in unmarked bottle in science classroom. It was dropped on the floor and kicked up and down the hallways. School closed for two weeks while it was decontaminated. Environmental sampling was done.
5/11/05 (6/6/05)	Spill - unknown amount	Y	Emergency Government / Emergency Services	Cedar Springs High School (Residential / Agricultural)	Kent	Section of Building and up to 50 feet (Building restricted)	Residence, School, Day Care, Business	Caller stated that a student dumped mercury onto the carpet in a classroom. Seven students were decontaminated at the scene. 1000 people were evacuated. Environmental sampling was done. Followed up with superintendent.
4/15/05 (same)	Spill/vapor released - unknown amount	Y	MDEQ	Litchfield Elementary School (Residential)	Hillsdale	Building and up to 100 feet	Residence, School, Business	Child brought mercury to school. It was spilled on the bus and taken into the school. 220 people were evacuated and school was closed while health officials tested shoes, clothes, and lockers for mercury. All students were decontaminated.
6/17/05	Spill - unknown amount	N - chronic	Emergency Government / Emergency Services	World Medical Relief (Commercial)	Wayne		Nursing Home, Business	Mercury released from manometers onto ground due to unknown causes; has been going on for years.
7/21/05	Spill - unknown amount	N - insufficient info	Emergency Government / Emergency Services	American Abatement (Residential)	Kalamazoo		Residence, Hospital, Business	Someone reported that this abatement company wasted some mercury and improperly cleaned it up.
8/10/05 (same)	Spill of 10 lbs	Y	Emergency Government / Emergency Services	Detroit Water and Sewage Dept (Industrial / Residential)	Wayne	Between 201 feet to 1/4 mile from point of release	Residence, School, Business	Mercury spilled onto the soil from a failed pneumatic flow meter. Company response team came and used vacuum until samples came back ok. No injuries.
8/10/05	Spill - unknown amount	N - small quantity	MDEQ	Home (Residential)	Kalamazoo		Residence, Business	Someone spilled mercury in car and vacuumed it up at a carwash using the carwash vacuum.
8/30/05 (same)	Spill of 10 lbs	Y	MDEQ	Detroit Water and Sewer Dept (Industrial / Residential)	Wayne	Immediate area and within 10 feet	Residence, School, Business	Mercury released from meters that were moved in an underground area. Hazmat came and vacuumed up the area. Environmental sampling was conducted. No injuries/evacuations. Followed up with MDCH.

TABLE 2-17: MERCURY RELEASES REPORTED TO MI-HSEES SINCE 2005

DATE OF EVENT (ACTION END DATE)	TYPE AND AMOUNT OF MERCURY RELEASED	DID EVENT MEET HSEES CRITERIA	WHO NOTIFIED MI-HSEES	LOCATION OF EVENT (TYPE OF AREA)	COUNTY	IMPACTED AREA OF RELEASE	TYPE OF FACILITIES WITHIN 1/4 MILE OF EVENT	SYNOPSIS
10/12/05 (10/24/05)	Spill/vapor of unknown amount released into environment	Y	Other government agency	Birch Run High School (Commercial / Residential)	Genesee	Building and up to 100 feet (Building restricted)	Residence, School, Day Care, Business	Student brought mercury to school where it was released in the cafeteria and tracked through the hallways. School officials did not tell anybody about this incident. It was one week later when a student mentioned it to a parent and the parent when to the media. The local public health department saw it on the news and responded with a health investigation eight days after the event. 630 people were evacuated and environmental sampling was done. The school was closed for one and a half school days and the weekend. There were no injuries or decontaminations.
2/3/06 (same)	Spill of 1.5 ounces (by volume)	Y	Emergency Government / Emergency Services	Habitat for Humanity (Commercial / Residential)	Oakland	Section of Building and up to 50 feet	Residence, Day Care, Business	Three foot medical thermometer dropped in a parking lot releasing mercury. Contractor cleaned up. No evacuations or injuries.
2/3/06 (same)	Spill/vapor of unknown amount	Y	Other government agency	Bank One (Commercial / Residential)	Wayne	Section of Building and up to 50 feet	Residence, Business	Unknown vandal deliberately put mercury into an ATM in Detroit. Lots of money was contaminated. Environmental sampling was conducted. No injuries.
3/10/06 (same)	Spill - unknown amount	Y	MDEQ	Metaldyne (Industrial)	Hillsdale	Immediate area and within 10 feet	Residence, Business	Mercury beads found outside an engine manufacturer. An electrician was changing a switch and spilled mercury. No evacuations/injuries. Clean-up contractor came and cleaned.
3/9/06 (3/10/06)	Spill - unknown amount	Y	Other Program Within MDCH	EAJ Memorial High School (Commercial / Residential)	Genesee	Section of Building and up to 50 feet (Room restricted)	Residence, School, Business	Thermometer dropped in a high school physics lab. Contractor cleaned, MDCH followed up and cleaned. The area of the school was evacuated, access to the room was restricted, and environmental sampling done. No injuries. Contractor cost was about $2000.
4/11/06 (4/13/06)	Spill - unknown amount	Y	Other Program Within MDCH	Fulton Middle School (Residential)	Gratiot	Building and up to 100 feet (Building restricted)	Residence, Business	A thermometer was broken at the school, 200 people were evacuated for one day for clean-up. Environmental sampling was done. No injuries.
4/17/06	Spill - unknown amount	N - not a hazardous substance	MDEQ	Home (Commercial / Residential)	Washtenaw	Immediate area and within 10 feet	Residence, Day Care, Business	Mercury spill in a fish tank (amount equivalent to that found in a thermostat).

TABLE 2-17: MERCURY RELEASES REPORTED TO MI-HSEES SINCE 2005

DATE OF EVENT (ACTION END DATE)	TYPE AND AMOUNT OF MERCURY RELEASED	DID EVENT MEET HSEES CRITERIA	WHO NOTIFIED MI-HSEES	LOCATION OF EVENT (TYPE OF AREA)	COUNTY	IMPACTED AREA OF RELEASE	TYPE OF FACILITIES WITHIN 1/4 MILE OF EVENT	SYNOPSIS
4/25/06 (5/2/06)	Spill - unknown amount	Y	Emergency Government / Emergency Services	Home (Residential)	Muskegon	Immediate area and within 10 feet	Residence, Business	Mercury spilled onto a bed. Health Dept. responded and took samples of the air to ensure clean-up. They recommended removal of the mattress (unknown if this was ever done). No injuries/evacuations.
4/24/06 (4/25/06)	Spill/vapor of unknown amount	Y	Media	Lakeland High School (Residential)	Oakland	Building and up to 100 feet (Room restricted)	Residence, School, Day Care, Business	Student dropped a mercury thermometer that they had brought to school. No injuries. 1505 people were evacuated for a day while the spill was cleaned up by a contractor. Clean-up cost was about $4500.
4/5/06 (same)	Spill/vapor of unknown amount released into environment	Y	Other Program Within MDCH	Munising High School (Residential)	Alger	Immediate area and within 10 feet (Room restricted)	Residence, School, Nursing Home, Day Care, Business	A broken psychrometer in a physics lab caused a release of mercury. 20 students were evacuated from the lab for two hours (until the end of school). Spill was cleaned up after school. Environmental air samples were taken the next morning before school to ensure proper clean-up.
5/10/06 (5/11/06)	Spill of 8 ounces (by volume)	Y	Other Program Within MDCH	Saginaw Valley State University (Commercial / Residential)	Saginaw	Section of Building and up to 50 feet (Room restricted)	Residence, Business, Recreational Area	Mercury spill on campus in science lab. Five people were in the lab at the time of the spill and were evacuated. A contractor was hired to ensure proper clean-up.
5/24/06 (5/26/06)	Spill of 0.5 ounces (by volume)	Y	Other Program Within MDCH	Home (Residential)	Allegan	Building and up to 100 feet	Residence, Business	A jar of mercury was knocked over when a couple was moving in. They evacuated the house immediately as she was pregnant. They contacted the MDEQ, poison control, and the local health department. A clean-up contractor came to clean-up remaining beads. Environmental sampling was done. There were no injuries.
6/5/06 (6/6/06)	Spill of 0.24 liters	Y	MDEQ	Parking lot (Commercial)	Ingham	Section of Building and up to 50 feet (Parking Lot restricted))	Residence, Business	Mercury found illegally dumped in the parking lot of an abandoned building. MDEQ and local health department responded and cleaned up area. Environmental sampling was done. No injuries.
7/8/06 (7/11/06)	Spill of 4 lbs	Y	Emergency Government / Emergency Services	Fire Department (Commercial / Residential)	Wayne	Building and up to 100 feet (Room restricted)	Residence, Day Care, Business, Recreational Area	Fireman knocked over a jar containing about 4 lbs of mercury. The area was isolated, local health dept and MDEQ helped with clean-up. No injuries. Area was restricted until proper clean-up was completed. Environmental sampling was done.

TABLE 2-17: MERCURY RELEASES REPORTED TO MI-HSEES SINCE 2005

DATE OF EVENT (ACTION END DATE)	TYPE AND AMOUNT OF MERCURY RELEASED	DID EVENT MEET HSEES CRITERIA	WHO NOTIFIED MI-HSEES	LOCATION OF EVENT (TYPE OF AREA)	COUNTY	IMPACTED AREA OF RELEASE	TYPE OF FACILITIES WITHIN 1/4 MILE OF EVENT	SYNOPSIS
8/1/06 (8/2/06)	Spill of 16 milliliters	Y	Other Program Within MDCH	Dr's Office (Commercial / Residential)	Wexford	Building and up to 100 feet (Building restricted)	Residence, Business	Sphygmomanometers spilled in a Dr's office. The room was sealed and isolated, a clean-up contractor came the next day and sampled and cleaned. The carpet was torn out and contaminated objects removed. No injuries/evacuations.
8/24/06 (8/29/06)	Spill - unknown amount	Y	MDEQ	Home (Commercial / Residential)	Wayne	Section of Building and up to 50 feet (Room restricted)	Residence, School, Day Care, Business	Mercury spill in a home. The Fire Dept. did an inadequate job of clean-up and the mercury was spread around. A health investigation was conducted. Ventilation was required to make sure that any remaining vapors dissipated. No injuries/evacuations.
9/28/06 (10/2/06)	Spill of 3 ounces (by volume)	Y	Other Program Within MDCH	Ontonagon Area High School (Residential)	Ontonagon	Section of Building and up to 50 feet (Room restricted)	Residence, School, Day Care, Business	Three students found mercury in a drawer in the wood shop and it was spilled onto the floor. The students and teacher were evacuated and the area was secured. Clean-up contractor came and cleaned the area. Environmental sampling was done and the area was restricted to students and staff until it the vapor levels had dissipated. No injuries.
10/3/06 (10/9/06)	Spill - unknown amount	Y	Other Program Within MDCH	Kingsford Middle School (Commercial / Residential)	Dickinson	Section of Building and up to 50 feet (Room restricted)	Residence, School, Nursing Home, Business	A teacher was doing a 'last time' demonstration using mercury when it spilled and contaminated the area. The teacher was suspended with pay. The area was sealed off and was sampled/cleaned by EPA contractor. There were no injuries.
10/1/06 (10/9/06)	Spill - unknown amount	Y	Other Program Within MDCH	Home (Residential)	Wayne	Entire facility and 101 to 200 feet beyond	Residence, School, Day Care, Business	Utility company spilled mercury from a furnace after maintenance was done. The utility company hired a clean-up contractor and had the furnace replaced. Environmental sampling was done. No injuries/evacuations.
10/7/06 (10/10/06)	Spill - unknown amount	Y	Other Program Within MDCH	Pine Crest Medical Care Facility (Commercial / Residential)	Menominee	Entire facility and 101 to 200 feet beyond (Room restricted)	Residence, Nursing Home, Business	An employee dropped a sphygmomanometer at a nursing station and carpet was removed. EPA and contractors called for environmental sampling and found more carpet removal was needed. No injuries/evacuations. The area was ventilated until there were acceptable readings. It was suggested that nursing home mercury education awareness be completed in the future.

TABLE 2-17: MERCURY RELEASES REPORTED TO MI-HSEES SINCE 2005

DATE OF EVENT (ACTION END DATE)	TYPE AND AMOUNT OF MERCURY RELEASED	DID EVENT MEET HSEES CRITERIA	WHO NOTIFIED MI-HSEES	LOCATION OF EVENT (TYPE OF AREA)	COUNTY	IMPACTED AREA OF RELEASE	TYPE OF FACILITIES WITHIN 1/4 MILE OF EVENT	SYNOPSIS
10/18/06 (10/19/06)	Spill of 2 ounces (by weight)	Y	Other Program Within MDCH	Flint Northern High School (Commercial / Residential)	Genesee	Building and up to 100 feet (Room restricted)	Residence, Day Care, Business, Recreational Area	Mercury was spilled at a high school and the school was evacuated for the afternoon. A teacher attempted to clean-up the spill and was taken to hospital as a precaution, he was not injured. MDCH consulted and environmental sampling was done.
11/16/06 (11/22/06)	Spill - unknown amount	Y	Emergency Government / Emergency Services	School (Commercial / Residential)	Van Buren	Entire facility and 101 to 200 feet beyond (Room restricted)	Residence, School, Business	Barometer fell off a shelf in a storage room when it snagged on a students shirt and spilled onto the floor. The student immediately changed his clothing and bagged it. The storage room was restricted but the school was not evacuated. Clean-up contractor took samples to ensure proper clean-up.
12/6/06 (Pending)	Spill/vapor of unknown amount released into environment	Y	Media	Chelsea High School (Commercial / Residential)	Washtenaw	Immediate area and within 10 feet (Section of Building Restricted)	Residence, School, Day Care, Business	Mercury thermometer dropped in science room. School locked down initially, then students returned to class avoiding the area. Hazmat team responded.
12/17/06 (Pending)	Spill/vapor of unknown amount released into environment	Y	Other Program Within MDCH	Home (Residential)	Wayne	Building and up to 100 feet (Building restricted)	Residence	Woman smelled gas leak and utility company responded. Technician removed mercury regulator, spilling mercury. Homeowner was evacuated and utility company is cleaning, ventilating, and guarding house until resident returns.
1/4/07 (Pending)	Spill/vapor of unknown amount released into environment	Y	Other Program Within MDCH	Carmen-Ainsworth High School (Residential)	Genesee	(Building Restricted)	Residence, School, Day Care	Spilled mercury found in science classroom. 40-50 students were potentially exposed and school was evacuated. Local health dept provided a health investigation and environmental consultants providing testing and clean-up.
1/5/07 (Pending)	Spill/vapor of unknown amount released into environment	Y	Other Program Within MDCH	Hamtramck Charter Academy (Commercial / Residential)	Wayne	(Room Restricted)	Residence, School, Business	Poison control reported mercury release in school. Student brought in a thermometer. Environmental sampling was done.
1/8/07 (Pending)	Spill/vapor of unknown amount released	Y	Other Program Within MDCH	Pine River Middle School (Residential / Agricultural)	Osceola		Residence, School, Business	Mercury released at a school, environmental sampling was done.

TABLE 2-17: MERCURY RELEASES REPORTED TO MI-HSEES SINCE 2005

DATE OF EVENT (ACTION END DATE)	TYPE AND AMOUNT OF MERCURY RELEASED	DID EVENT MEET HSEES CRITERIA	WHO NOTIFIED MI-HSEES	LOCATION OF EVENT (TYPE OF AREA)	COUNTY	IMPACTED AREA OF RELEASE	TYPE OF FACILITIES WITHIN 1/4 MILE OF EVENT	SYNOPSIS
1/5/07	Spill/vapor of unknown amount released	Y	Other Program Within MDCH	Birmingham Covington School (Commercial / Residential)	Oakland	Immediate area and within 10 feet (Room restricted)	Residence, School, Business	Twelve inch long mercury thermometer broke at school. Teacher swept mercury into a waste basket. Clean-up contractor came, local health dept involved, environmental sampling was done.
1/8/07 (Pending)	Spill/vapor of unknown amount released	Y	Other Program Within MDCH	Eaton Rapids High School (Commercial / Residential)	Eaton	Building and up to 100 feet	Residence, School, Day Care, Business	Student brought necklace from Mexico into school. Mercury was released, students played with it in the hall before contacting a teacher. Five students taken to local hospital. Environmental sampling was done.
1/25/07 (same)	Spill of 28 milliliters	Y	MDEQ - Info taken from NRC report, PEAS report and MDCH follow-up.	Detroit Zoo - Penguin House (Recreational)	Oakland	Section of Building and up to 50 feet	Residence, Business, Recreational Area	Mercury (approximately 2 tablespoons) was spilled in an office of the Penguin House in the Detroit Zoo. Person contacted the NRC for assistance with spill clean-up. MDCH contacted and guided the effort along with local health department and EPA. One pregnant office worker was relocated as a precaution.
1/27/07 (Pending)	Spill/vapor of unknown amount released	Y	Other Program Within MDCH	Home	St. Clair		Residence, Business	Child found dime sized bead of mercury that had fallen from a mercury filled clutch.
1/26/07 (1/31/07)	Spill <1 ounce	Y	Media	Sherman Middle School (Residential)	Oakland	Immediate area and within 10 feet (Room restricted)	Residence, School, Day Care, Business	Pea-sized spill from a vial in school science kit. Three people were evacuated while room was cleaned and tested. No trace found on clothes of student who dropped vial. No injuries. Environmental sampling was done and room was closed until test results showed no contamination.

2.6.2 LARGE HG(0) SPILLS

Should a 'large' mercury spill occur, which is defined by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) as a spill equal to or exceeding 1 lb (> 2 tablespoons) that either is or has the potential to be released to the environment, federal regulations require the spill incident to be reported to: the NRC,[50] MDEQ's PEAS (discussed previously), HSEES (MDCH's MI-HSEES program info is in **Chapter 2.6.1**), and SARA (Superfund Amendments and Reauthorization Act of 1986) Title III Program (Emergency Planning and Community Right-to-Know Act). [51] The following are brief program descriptions of the NRC, SARA Title III, and ATSDR HSEES.

NATIONAL RESPONSE CENTER (NRC)

The primary function of the NRC is to serve as the sole national point of contact for reporting all oil, chemical, radiological, biological, and etiological discharges into the environment anywhere in the U.S. and its territories. The NRC is staffed by Coast Guard personnel who maintain a 24 hour per day, 365 day per year telephone watch. NRC watch standers enter telephonic reports of pollution incidents into the Incident Reporting Information System and immediately relay each report to the pre-designated Federal On-Scene Coordinator (FOSC) who coordinates all federal containment, removal, disposal efforts, and resources during an incident. The FOSC, pre-designated by EPA for inland areas and by the Coast Guard for coastal or major navigable waterways, also coordinate federal efforts with local community responses.

The Incident Reporting Information System developed by the Space and Naval Warfare Systems Center Charleston, National Capital Region, is central to all NRC operations. The NRC also provides emergency response support to the FOSCs and has the ability to quickly place them in direct contact with expert technical support centers (ATSDR, CDC, etc.) if needed. In addition to gathering and distributing spill data for the FOSC, the NRC maintains agreements with a variety of federal entities to make additional notifications regarding incidents meeting established trigger criteria. The following are just a few examples of the NRC tasks, in relationship to hazardous waste (i.e., mercury):

- Receives and relays reports of incidents reportable under the Hazardous Materials Transportation Act;
- Provides electronic and hard copy incident reports to various Department of Transportation agencies;
- For the EPA, the NRC receives incident reports under the Federal Response System which is supported under the CERCLA, CWA, Clean Air Act (CAA), SARA Title III, and the Oil Pollution Act of 1990. The NRC disseminates telephonic and electronic (fax, email) reports of oil discharges and chemical releases to the EPA FOSC;
- For the Department of Health and Human Services, releases of etiological and biological agents are recorded at the NRC and referred to the CDC;
- For the Federal Railroad Administration, the NRC maintains the 24-hour Rail Emergency Hotline (1-800-424-0201) to take reports of railroad incidents involving hazardous materials, etc.

[50] The toll-free phone number for the NRC is 800-424-8802.
[51] Local Emergency Planning Committee contacts can be obtained from the Michigan SARA Title III program at 517-373-8481.

- Additionally, the NRC is the contact point for activation of the National Response Team (NRT) and provides facilities for the NRT to use in coordinating a national response action when required. The NRT consists of 16 federal agencies with interest and expertise in various aspects of emergency response to pollution incidents. The NRT is a planning, policy, and coordinating body, providing national level policy guidance and can provide assistance to a FOSC during an incident, usually in the form of technical advice or access to additional resources and equipment at the national level.

Table 2-18 provides a brief description of 89 Michigan mercury-related incidents (with an approximate total release of more than 1,500 lbs of mercury) that were reported to the NRC from 1990 to February 2007.[52]

TABLE 2-18: NRC REPORT ON MERCURY-RELATED INCIDENTS IN MICHIGAN FROM 1990 TO 2007

DATE	QUANTITY OF HG	COUNTY	COMMENTS
02/15/90	.13 gallons	Wayne	Mercury in a locker leaked out due to unknown cause.
04/24/90	2 lbs	Bay	Test equipment fell off of a shelf.
05/18/90	10 lbs	Wayne	Material spilled when manometer was moved and broken.
05/30/91	2.39 lbs	Saginaw	Broken mercury monitor (pressure gauge) / operator error
05/30/91	2.4 lbs	Saginaw	Broken manometer (pressure gauge)
07/14/91	unknown	Berrien	Vandals poured mercury down the sink drain
07/24/91	8 lbs	Calhoun	Equipment failure of manometer on fire system
02/17/92	3 lbs	Wayne	Arc welding tubes broke open during disposal
06/23/92	12 lbs	Alpena	Belt scale was tipped over
07/14/92	unknown	Wayne	Old paint factory's material/excavated contaminated soil.
05/10/93	1 lbs	Wayne	Unknown piece of equipment leaking from a box
07/09/93	unknown	Genesee	Popcorn machine mercury switch exploded inside equipment
10/14/93	1 lbs	Kent	1 pint jar knocked over and broke; cleaned up with dry sulfur.
02/08/94	1.17 lbs	Saginaw	Flow meter leaked due to ruptured piping
05/13/94	156 lbs (10 lbs-water)	Wayne	Storage tank/feed line connection broke loose.
10/31/94	3 lbs	Macomb	Material discovered in an elevator shaft.
01/03/95	10 lbs	Macomb	Glass bottle in tool box was knocked over; contractor hired.
06/28/95		Manistee	Multiple materials involved
10/08/95	.01 gallon	Macomb	Unknown sheen on concrete.
08/05/96	1 cup	Genesee	Pump room gauge spilled into a sump
03/20/97	8 ounce	Montcalm	Old 60's sludge dryer being cleaned up and material spilled.
06/26/97	10 gallon	Wayne	Spill contained inside a tractor trailer.
04/14/98	5 lbs	Macomb	Manometer leak.
07/07/98	Unknown	Delta	Paper mill dumping sawdust laced with mercury in the water.
03/02/99	Unknown	Wayne	Mercury vapors detected through-out a building for sale.
10/20/99	16 ounces	Berrien	Kids played with vial found in a bldg and 1 took it home.
03/27/00	Unknown	Monroe	Son removed mercury from school, portions were returned.
06/06/00	1 lbs	Lenawee	Small pool of mercury discovered on owner's barn floor.
07/13/00	1 gallon	Wayne	Mercury spill in alley; been there for several weeks.
07/20/00	1 ounce	Wayne	A vial broke when cataloging the removal from school lab.
08/23/00	Unknown	Wayne	Significant release from a dropped meter being replaced.

[52] NRC data can be queried on-line via the website at www.nrc.uscg.mil/foia.html.

TABLE 2-18: NRC REPORT ON MERCURY-RELATED INCIDENTS IN MICHIGAN FROM 1990 TO 2007

DATE	QUANTITY OF HG	COUNTY	COMMENTS
08/24/00	.5 ounces	Wayne	Mercury found on the curb in front of residence.
09/17/00	Unknown	Macomb	During renovation in rafters of home a container fell over.
09/19/00	Unknown	Macomb	Thermometer dropped and broke onto bathroom floor.
09/29/00	1 lbs	Wayne	A tank gauge system failed due to compressor tube fitting.
10/18/00	2300 ppm	Kent	Contaminated soil at old industry washing into Grand River.
10/26/00	unknown	Washtenaw	During transport, manometer tilted and leaked.
10/26/00	1.25 lbs	Livingston	Mercury switch overloaded with current and blew out.
11/20/00	1 lbs	Genesee	Accidental spill from a control leveler.
12/06/00	Unknown	Macomb	Thermometer broke and spilled mercury onto the carpet.
01/23/01	Unknown	Wayne	Small container of mercury in a storage area was broken.
03/12/01	Unknown	Oakland	Mercury discovered in bottom of a drain in a janitor's closet.
03/19/01	1 lbs.	Genesee	Mercury was found on the side of the road.
04/30/01	Unknown	Wayne	Previous spill from bldg machines inadequately cleaned?
04/30/01	1 pint	Wayne	A level monitoring device dropped spilling mercury on floor.
06/06/01	Unknown	Wayne	A thermometer was dropped and broke on the floor
06/26/01	Unknown	Keweenaw	A thermometer fell and broke onto the floor.
07/16/01	.5 cup	Kent	Two thermometers broke and container of mercury found.
07/23/01	Unknown	Genesee	A thermostat's bulb broke onto the floor.
07/27/01	1 lbs	Jackson	Sphygmomanometer in a box broke.
09/29/01	.5 teaspoon	Oakland	Thermometer broke during garage renovation.
10/11/01	.5 lbs.	Wayne	Mercury spill in science class spread 100 ft. with foot traffic.
12/01/01	1 lbs	Livingston	Blood pressure unit was broken in an exam room.
03/06/02	2 ounces	Wayne	Blood pressure equipment was broken when thrown in trash.
04/03/02	12 ounces	Monroe	Postal employee loading truck when package began leaking.
05/21/02	11 lbs	St. Clair	Chart recorder equipment fell and broke.
05/24/02	2 drops	Macomb	Thermometer broke on tile floor inside nursing home.
06/24/02	3 ounces	Macomb	Faulty blood pressure cuff leaking while being transferred.
08/26/02	Unknown	Wayne	Abandoned pickup truck appeared to be releasing mercury.
10/13/02	Unknown	Wayne	Blood pressure machine leaked throughout home.
10/21/02	Unknown	Wayne	Mercury flame censor switch leaked into home furnace.
12/08/02	1 drop	Wayne	Broken thermometer.
05/02/03	1 ounce	Monroe	Release of mercury from an unknown source.
06/24/03	Unknown	Washtenaw	Hole in tube on temperature transmitter - holds 1 lb of Hg.
09/21/03	1 ounce	Kent	Thermometer spilled inside of a closet.
10/22/03	5 ounces	Benzie	Mercury discovered in the woods, origin unknown.
11/11/03	Unknown	Oakland	Spill while removing Hg from old blood pressure units.
03/09/04	4 lbs	Genesee	Pressure measurement device spill during class experiment.
04/02/04	Unknown	Jackson	A mercury manometer broke in a chemistry lab.
06/07/04	1.5 lbs	Eaton	A manometer malfunctioned.
06/11/04	2 cups	Oakland	While snaking a drain, Hg spilled from the drain in basement.
04/15/05	Unknown	Hillsdale	Child found Hg in a shed, passed around elementary/high school bus and in the school halls and classrooms.
04/30/05	1 pint	Wayne	During renovation of abandoned house, jar of Hg spilled.
05/10/05	Unknown	Calhoun	Student brought container to school, kicked around hallways.
05/11/05	Unknown	Kent	Student dumped mercury onto classroom carpet.
06/17/05	Unknown	Wayne	Continuous release of Hg onto ground from manometers.

TABLE 2-18: NRC REPORT ON MERCURY-RELATED INCIDENTS IN MICHIGAN FROM 1990 TO 2007

DATE	QUANTITY OF HG	COUNTY	COMMENTS
07/21/05	Unknown	Kalamazoo	Report of improper cleaning of spilled Hg.
08/10/05	10 lbs	Wayne	Mercury spilled on soil from failed pneumatic flow meter.
12/27/05	1 cup	Baraga	Discovery of small pools of Hg left on a pavement surface.
01/19/06	Unknown	Wayne	Report of a release of mercury onto the floor within a home.
02/03/06	3 tablespoons	Oakland	A 3 foot long medical thermometer was dropped.
04/25/06	Unknown	Muskegon	Thermometer broke onto a bed and moved by hand.
06/20/06	Unknown	Monroe	Hg found in basement; family evacuated due to high levels.
07/08/06	1 lbs	Wayne	Operator error in release of Hg at fire department.
09/28/06	Unknown	Ontonagon	Students looking for equipment spilled Hg from a container.
10/01/06	3 beads (.25 size ea)	Oakland	Hg found in basement from previous year's replaced meter.
10/03/06	Unknown	Dickinson	Mercury released from a vial due to operator error.
11/16/06	2 tablespoons	Van Buren	A barometer fell off a shelf in a classroom's storage area.
01/25/07	Unknown	Oakland	Hg container spilled and broke inside an office building.

SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT (SARA) TITLE III PROGRAM

An additional MDEQ data source where large mercury spills occurring in Michigan are tracked and recorded is through the SARA Title III program summarized in **Table 2-19**. After conducting a database search for mercury spills, the query generated only two mercury spill incidents occurring within the designated timeframe with a release of approximately 12 lbs of mercury. However, it is important to note that this does not necessarily reflect all mercury releases reported to the MDEQ that were subject to reporting under Section 304 of the Michigan SARA Title III Program.

TABLE 2-19: FOLLOW-UP MERCURY RELEASE REPORTS PURSUANT TO SARA TITLE III PROGRAM SECTION 304 (1995 TO 2006)

REPORT DATES	AMOUNT OF HG RELEASED	COMPANY	LOCATION	COMMENTS
11/20/00 to 12/01/00	1 lbs	GM Service Parts Operation Plant-01 (Flint)	Swartz Creek	CERCLA - None released to the environment
5/21/02 to 6/4/02	approx. 11 lbs	E.B. Eddy Paper	Port Huron	

HAZARDOUS SUBSTANCES EMERGENCY EVENTS SURVEILLANCE (HSEES)

In 1990, the ATSDR established the HSEES system to collect and analyze information about acute releases of hazardous substances that need to be cleaned up or neutralized according to federal, state, or local law, as well as threatened releases that result in a public health action such as an evacuation.[53] The decision to initiate a surveillance system of this type was based on a study published in 1989 about the limitations in the reporting of hazardous substances releases to three national databases: the NRC, the Hazardous Material Information System, and the Acute Hazardous Events. The goal of HSEES is to:

- Describe the distribution and characteristics of acute hazardous substances releases;
- Describe morbidity and mortality among employees, responders, and the general public that resulted from hazardous substances releases;
- Analyze and describe risk factors associated with morbidity and mortality; and

[53] Information on the federal HSEES program is at http://www.atsdr.cdc.gov/HS/HSEES/hsees.html.

- Develop strategies that might reduce future morbidity and mortality resulting from the release of hazardous substances.

The HSEES system captures data on over 9,000 events annually from all participants. From 1993 to 2003, there were a total of 199 events related to mercury releases. According to the ASTDR's *HSEES 2003 Report*, in the last few years the emphasized goal of the HSEES system is to develop strategies to reduce subsequent morbidity and mortality by having each participating state analyze its data and develop appropriate prevention outreach activities.[54]

Beginning in 2006, mercury was added to the HSEES "mandatory reporting list," which means that any acute release of mercury is now required to be reported, such as thermometer breaks as well as other releases that involve some kind of response (i.e. clean-up contractor, MDEQ/EPA involvement, etc.). Under this new requirement, the number of mercury spills reported will increase.

In examining all the reported Hg(0) spills data (both large and small spills) for Michigan (for a variety of reporting years), there have been about 5,500 spills amounting to approximately 1,800 lbs of Hg(0) released to Michigan's environment. This demonstrates that Hg(0) spills in the state can be significant and efforts to prevent the use are important. The MSWG recommends that discussions be held on improved communication and collaboration on spill reporting from PEAS, NRC, and HSEES (which includes MI-HSEES) databases.

2.6.3 MERCURY SPILL CLEAN-UP

Many different agencies such as the MDEQ, EPA, poison control centers, MDCH, universities and numerous other sources found on the Internet, offer mercury spill clean-up advice. The MDEQ has listed many sources on its Mercury Spill Resources webpage including instructions for "*Cleaning up Small Mercury Spills*" and "*Steps for Responding to a Large Elemental Mercury Spill*."[55] However, it is important to note that sometimes the advice among the numerous sources are inconsistent and at times may offer conflicting statements. To rectify this confusion, MDEQ has been working closely in conjunction with MDCH, poison control centers, and county environmental health departments to develop consistent spill response guidelines. Over time as technology advances and the knowledge of spill response experience grows, it is becoming evident that additional updates and revisions of these guidelines are warranted.


Steps for Responding to a Large* Elemental Mercury Spill

Appendix M contains a list of professional mercury spill response and environmental clean-up contractors that were compiled by the MDEQ.[56] However, there is some concern surrounding the fact that mercury spill clean-up contractors undergo no formal licensing, testing or certification procedure. At this time anyone is able to call themselves a "clean-up contractor." In response to this concern, the MDEQ, MDCH and the Detroit Mercury Task Force (see **Chapter 4.4.9**) joined forces to assemble and conduct a series of Mercury Spill Response Training workshops. Nearly two dozen workshops have been held to train front line responders in proper methods and techniques for mercury spill response and the MDCH and MDEQ are frequently

[54] The HSEES 2003 annual report is available at http://www.atsdr.cdc.gov/HS/HSEES/annual2003.pdf
[55] Mercury Spill Resources: http://www.michigan.gov/deq/0,1607,7-135-3307_29693_4175-11690--,00.html.
[56] The list of mercury clean-up contractors was compiled by the MDEQ for informational purposes only.

requested to repeat these sessions in various locations and for various audiences throughout Michigan. The MSWG recommends that this process continue as resources allow and when warranted, and that a minimum of two such events are conducted annually.

Mercury spill clean-up kits are currently available by various suppliers. **Table 2-20** lists the suppliers and their phone number. However, it should be noted that this list was compiled by the MDEQ to provide information about potential sources of mercury remediation equipment. The quality of service provided by each company is not known or implied by this listing.[57]

TABLE 2-20: SUPPLIERS OF MERCURY SPILL CLEAN-UP KITS

COMPANY	PHONE NUMBER
Abatix Environmental Supply	253-735-1960
Advanced Environmental Solution	253-735-1960
Fisher Scientific	800-766-7000
Flinn Scientific	800-452-1261
Lab and Safety Supply (Safety Essentials Catalog)	800-356-0783
Lamp Recyclers of Louisiana, Inc. (sells a Mercury 'Magnet' Spill Kit)	800-309-9908
Mallinckrodt/Baker (manufactures several spill kits)	800-852-2537
OMNI/ajax	570-848-4186
Safety Tech Line	800-356-2501
Sanderson Safety Supply Co.	206-340-4300
VWR Scientific	800-932-5000

To assist home owners in spill clean-ups and due to various funding sources (discussed in **Chapters 4.2.10** and **6.1.1**), the MDCH and a number of Michigan local public health departments now have a Lumex RA-915+ (shown at right) or a 915 Light mercury vapor analyzer. A Lumex mercury vapor analyzer is a portable device that facilitates instantaneous Hg(0) air concentration readings in homes, schools, and businesses where Hg(0) has been spilled. The MDCH and these local public health departments use the Lumex for identifying where there is indoor contamination and to assess the hazard. Following clean-up activities, the Lumex is again used to confirm whether concentration levels are back to a safe concentration in the air in accordance to the MDCH's "*Suggested Action Levels for Indoor Mercury Vapor in Michigan*" (see **Appendix N**) (Boyle and De Rosa, 2000).

Table 2-21 provides information on the local public health departments, including the counties that they service, that either own or have access to a Lumex mercury vapor analyzer. **Figure 2-10** is a map showing their locations.[58]

[57] The MDEQ does not recommend or endorse the products of any particular company listed herein, does not inspect these facilities, and does not represent that the companies are, or are not, in compliance with applicable federal and state environmental laws.

[58] For a complete listing of all of Michigan's 45 city, county, and district health departments, visit the Michigan Association for Local Public Health website at http://www.malph.org/page.cfm/108/.

TABLE 2-21: MICHIGAN LOCAL HEALTH DEPARTMENTS THAT USE LUMEX MERCURY VAPOR ANALYZERS

NAME	COUNTY	ADDRESS	CITY	ZIP CODE	PHONE NUMBERS (FAX)	WEBSITE ADDRESS
*Allegan County Health Dept.	Allegan	3255 122nd Ave., Suite 200	Allegan	49010	269-673-5411, (269-673-4172)	www.allegancounty.org
Bay County Health Dept.	Bay	Washington Park Plaza, 1200 Washington Ave.	Bay City	48708	989-895-4009, (989-895-4014)	www.baycounty-mi.gov
Central Michigan District Health Dept.	Arenac, Clare, Gladwin, Isabella, Osceola, and Roscommon	2012 E. Preston Ave.	Mt. Pleasant	48858	989-773-5921, (989-773-4319)	www.cmdhd.org
**Detroit Dept. of Health and Wellness Promotion	Wayne	1151 Taylor	Detroit	48202	313-876-4000, (313-871-5363)	http://www.dethealth.org/
Genesee County Health Dept.	Genesee	630 S. Saginaw St.	Flint	48502-1540	810-257-3612, (810-257-3147)	http://www.gchd.us
Ingham County Health Dept.	Ingham	5303 S. Cedar, P.O. Box 30161	Lansing	48909	517-887-4311 (517-887-4310 or 517-887-4396)	www.ingham.org
*Kalamazoo County Health and Community Services Dept.	Kalamazoo	3299 Gull Rd., P.O. Box 42	Nazareth	49074-0042	269-373-5200, (269-373-5363)	www.kalcounty.com/hcs
*Kent County Health Dept.	Kent	700 Fuller Ave., N.E.	Grand Rapids	49503	616-632-7100, (616-632-7084)	www.accesskent.com
Macomb County Health Dept.	Macomb	43525 Elizabeth Rd.	Mt. Clemens	48043	586-469-5235, (586-469-5885)	www.macombcountymi.gov/publichealth
Marquette County Health Dept.	Marquette	184 U.S. 41 Highway	Negaunee	49866	906-475-9977, (906-475-9312)	www.mqthealth.org
***Monroe County Health Dept.	Monroe	2353 S. Custer Rd. (M-50)	Monroe	48161	734-240-7800, (734-240-7814)	www.co.monroe.mi.us/publichealth
Northwest Michigan Community Health Agency	Antrim, Charlevoix, Emmet, and Otsego	220 W. Garfield St.	Charlevoix	49720	231-547-6523, (231-547-6238)	www.nwhealth.org
Oakland County Health Division	Oakland	1200 N. Telegraph Rd.	Pontiac	48341-0432	248-858-1280, (248-858-5639)	www.co.oakland.mi.us
Saginaw County Dept. of Public Health	Saginaw	1600 N. Michigan Ave.	Saginaw	48602	989-758-3800, (989-758-3750)	www.saginawpublichealth.org
Washtenaw County Public Health Dept.	Washtenaw	555 Towner Ave, P.O. Box 915	Ypsilanti	48197-0915	734-544-6700, (734-544-6704)	http://publichealth.ewashtenaw.org
***Wayne County Health Dept.	Wayne	33030 Van Born Rd.	Wayne	48184	734-727-7000, (734-727-7043)	http://www.waynecounty.com/hhSvcs/public/default.htm
Western Upper Peninsula District Health Dept.	Baraga, Gogebic, Houghton, Keweenaw, and Ontonagon	540 Depot	Hancock	49930	906-482-7382, (906-482-9410)	www.westernuphealth.org

*Allegan and Kent County Health Departments do not own a Lumex but can use Kalamazoo County's Lumex when needed.
**Detroit Department of Health does not own a Lumex but can borrow one from a local Detroit industrial source when needed.
***Monroe County Health Department does not own a Lumex but can use Wayne County's Lumex when needed.

FIGURE 2-10: MICHIGAN LOCAL HEALTH DEPARTMENTS THAT UTILIZE LUMEX MERCURY VAPOR ANALYZERS FOR IDENTIFYING INDOOR MERCURY SPILLS

Michigan State University Center for Remote Sensing and Geographic Science (www.crs.msu.edu) "Base Map"

3. REGULATIONS THAT ADDRESS MERCURY RELEASES TO THE ENVIRONMENT, DISPOSAL, REUSE AND REMEDIATION OF CONTAMINATED SITES IN MICHIGAN

Michigan utilizes its base regulatory programs to reduce mercury releases to the environment in media such as air, water, soil, and waste (**Table 3-1**). The following chapters list these programs that regulate mercury from air point sources, water discharges and waterbody nonattainment (Total Maximum Daily Loads [TMDL]), soils, and waste (solid and hazardous waste). Also included in this chapter are state use limits and state legislation that limits the use or release of mercury.

TABLE 3-1: ENVIRONMENTAL MERCURY STANDARDS AND OR GUIDELINES FOR MICHIGAN (STANDARD OR RULE REFERENCE)

AIR			WATER							
AMBIENT AIR	INDOOR AIR		SURFACE WATER			GROUNDWATER EXPOSURE			DRINKING WATER	BIOSOLIDS
Inhalation Exposure Only (EPA RfC)* 0.3 µg/m^3	ATSDR Residential Clean-up Guidelines** 1 µg/m^3	Industrial (OSHA) [8 hr/day, 40 hr/work week] 50 µg/m^3	Human Health Protection 1.8 ng/L (Fish Tissue Value is 0.35 MeHg/kg)***	Wildlife Health Protection 1.3 ng/L	Surface to Groundwater Contact 56,000 ng/L	To Drinking Water 2 ppb	Venting to Surface Water 1.3 ng/L	Protective for Vapor Intrusion & Groundwater Contact 56 ppb [mercury water solubility limit]	2 ppb	Land Applied 17 ppm; Ceiling of 57 ppm

SOIL							WASTE				
SOIL EXPOSURE							TOXIC HAZARDOUS WASTE	LOW HG WASTE	HIGH HG WASTE	HG(0) WASTE	LAND-APPLIED SOLID WASTE
Direct Contact 16 ppm	PROTECTIVE OF						0.2 mg/L [TCLP Method 1311)****	260 ppm [Total Hg]	260 ppm	260 ppm [Total Hg]	0.13 ppb [back-ground criteria] *****
	Groundwater Venting to Surface Waters 100 ppb [detection level]	Groundwater Contact 46,000 ppb	Vapor Intrusion 48,000 ppb	Volatile Soil Inhalation 52,000 ppb	Particulate Inhalation 20,000 ppm	Drinking Water 1,700 ppb					

*24-hour averaging time
**Clean-up guidelines are used after removal of all Hg source. Reference: Boyle and De Rosa, 2000.
***Fish tissue value is also used in Michigan as an indication of whether the human health water quality value is being met.
****Waste is defined as toxic hazardous waste if extract from a representative sample exceeds regulatory standard using TCLP Method 1311; standard modeled upon mobility of mercury from waste disposed in a solid waste landfill and the potential for drinking water contamination.
*****By meeting background criteria the material may be designated inert per solid waste regulations and may be land applied for beneficial purposes.

Acronyms: ATSDR = Agency for Toxic Substance and Disease Registry; Hg = mercury; Hg(0) = elemental mercury; hr = hour; MeHg/kg = methylmercury per kilogram; ng/m^3 = nanograms per cubic meter; OSHA = Occupational Safety and Health Administration; ppb = parts per billion; ppm = parts per million; ppt = parts per trillion; RfC = inhalation reference concentration; TCLP = Toxicity Characteristic Leaching Procedure ng/L=ppt, 1 ppb=1,000 ppt, 1ppm=1,000 ppb

3.1 AIR

The MDEQ's Air Quality Division (AQD) ensures that Michigan's air remains clean by regulating sources of air pollutants to minimize adverse impact on human health and the environment. Goals are to meet and maintain air quality standards, limit emissions of hazardous and toxic pollutants, and inform the public about current air conditions. The following chapters discuss the federal CAA and the state's air programs that address mercury releases.

3.1.1 FEDERAL CLEAN AIR ACT (CAA)

The federal CAA requires EPA to regulate emissions of toxic air pollutants, including mercury, from a published list of industrial sources referred to as "source categories." As required under the CAA, EPA has developed a list of source categories that must meet control technology requirements for these toxic air pollutants. EPA is required to develop regulations (rules or standards) for all industries that emit one or more of the pollutants in significant quantities. **Table 3-2** lists EPA's promulgated standards under 40 Code of Federal Regulation (CFR) and their potential impact on mercury reduction and **Table 3-3** contains forthcoming standards intended for mercury reduction.

TABLE 3-2: PROMULGATED FEDERAL AIR EMISSIONS STANDARDS THAT ACHIEVE SOME MERCURY REDUCTION

(Compliance is already required, except where otherwise noted) – (Source: EPA, Region 5)

REGULATED FACILITIES	CITATION IN 40 CFR	MERCURY LIMITS	POTENTIAL MAGNITUDE OF EMISSIONS REDUCTIONS	FACILITIES IN MICHIGAN	OTHER COMMENTS
Hospital/Medical/ Infectious Waste Incinerators	Federal Plan Requirements – Part 62, Subpart HHH NSPS – Part 60, Subpart EC Emissions guidelines for existing sources – Part 60, Subpart CE	New and Existing sources - 0.55 mg/dscm, or 85% control Small rural sources – 7.5 mg/dscm Facilities required to develop waste management plans	Estimated reductions in EPA Region 5 from 10.6 tons in 1990 to 0.13 tons in 1999	0 (as of 6/04)	State plans New source = construction began after 6/20/96 (Michigan has adopted stricter rules)
Large Municipal Waste Combustors	Federal Plan Requirements – Part 62, Subpart FFF NSPS – Part 60, Subpart Eb Emissions Guidelines for existing sources – Part 60, Subpart Cb	New and existing sources – 0.08 mg/dscm, or 85% control	Estimated reductions in EPA Region 5 from 8 tons in 1990 to 0.823 tons in 1999, with additional subsequent reductions from full implementation of both small & large combustors regulations	2 (as of 9/10/04)	State plans New sources = construction began after 9/20/94
Small Municipal Waste Combustors	NSPS – Part 60, Subpart AAAA Emissions Guidelines for existing sources – Part 60, Subpart BBBB	New and existing sources – 0.08 mg/dscm, or 85% control		1 as of 9/10/04	State plans New sources = construction after 8/30/99; modification after 6/6/01. Compliance by 12/6/05
Commercial/ Industrial/ Institutional Boilers	Part 63, Subpart DDDDD (EPA vacated emission limits in 2007)	New or reconstructed solid fuel units (all large, small, and limited use units) – 0.000003 lbs/MMBtu heat input Existing large solid fuel units (greater than 10 MMBtu)– 0.000009 lbs/MMBtu heat input Some potential reductions from PM controls required at liquid fuel units	Estimated nationwide reduction from 12 tons to 10 tons. Estimated EPA Region 5 emissions in 1999 – 1.5 tons (likely understates Regional share, due to inclusion of some boilers in other sectors.)	~ 393 (an estimated 5,562 boilers are subject to the rule nationally)	Compliance for existing boilers by 9/13/07 New or reconstructed units by 11/12/04 New sources = construction begins after 1/13/03
Electric Utility Boilers	Part 60, Subpart HHHH	Implemented through state plans with option for participating in nationwide cap and trade program	Should be significant with implementation of CAMR and state rule (Michigan developing rules requiring 90% by 2015)	22	Regulations required - 2010; additional reductions - 2018

TABLE 3-2: PROMULGATED FEDERAL AIR EMISSIONS STANDARDS THAT ACHIEVE SOME MERCURY REDUCTION (CONTINUED)
(Compliance is already required, except where otherwise noted) – (Source: EPA, Region 5)

REGULATED FACILITIES	CITATION IN 40 CFR	MERCURY LIMITS	POTENTIAL MAGNITUDE OF EMISSIONS REDUCTIONS	FACILITIES IN MICHIGAN	OTHER COMMENTS
Mercury-Cell Chlor-Alkali Plants	Part 63, Subpart IIIII	Mercury emissions prohibited from new or reconstructed sources Existing sources (52 week rolling average) End box ventilation system vent and by-product hydrogen stream (when both present) - 0.076 g/mg chlorine produced By-product hydrogen stream (when no end box ventilation system present) – 0.033 g/mg chlorine produced Mercury recovery facility (oven-type thermal recovery unit) – 23 mg/dscm Mercury recovery facility (non-oven type thermal recovery unit) – 4 mg/dscm Extensive work practice requirements for mercury cell room	Estimated nationwide reduction of 1500 lbs/yr (74% reduction) resulting from emissions standards; additional reductions from work practice standards not quantified. Proportional reduction in EPA Region 5 would be more than 300 lbs.	0 (only legacy sites)	Compliance by 12/19/06. Standard has been challenged in court. In the meantime, sources must comply with the old mercury NESHAP.
Hazardous Waste Incinerators (interim standards) (see **Table 3-3** for proposed new standards)	Part 63, Subpart EEE	Incinerators new – 45 µg/dscm; existing – 130 µg/dscm Cement kilns new and existing - 120 µg/dscm Lightweight aggregate kilns new and existing – 120 µg/dscm	Estimated 55% reduction in sources accounting for 6.57 tons annually nationwide, and 0.8 tons in EPA Region 5	2	
Commercial and Industrial Solid Waste Incinerators	Part 60, Subpart CCCC (new sources after 11/30/99) Part 60, Subpart DDDD (existing sources)	New and existing sources– 0.47 dscm Waste management plans required	34% reduction from existing units – from 0.85 tons to 0.56 tons nationwide (according to EPA 65 Federal Register (FR) 75346)	~ 9	Compliance for existing sources required three years after state plan approval - no later than 12/1/05. Federal Plan in all states except Indiana.
Other Solid Waste Incinerators	Part 60, Subpart EEEE and FFFF	Very small municipal and institutional incinerators 74 µg/dscm			Consent decree for final rule by 11/30/05

TABLE 3-2: PROMULGATED FEDERAL AIR EMISSIONS STANDARDS THAT ACHIEVE SOME MERCURY REDUCTION (CONTINUED)
(Compliance is already required, except where otherwise noted) – (Source: EPA, Region 5)

REGULATED FACILITIES	CITATION IN 40 CFR	MERCURY LIMITS	POTENTIAL MAGNITUDE OF EMISSIONS REDUCTIONS	FACILITIES IN MICHIGAN	OTHER COMMENTS
Taconite Processing	Part 63, Subpart RRRRR	No emissions limit for mercury. PM controls will achieve mercury reduction at some facilities.	National Emission Inventory estimates total emissions of 0.235 tons in Region 5; Minnesota Pollution Control Agency estimates 0.3725 tons in Minnesota alone	2	Compliance required by 10/30/06. EPA agreed to reconsider developing mercury emissions standards in light of new information about potential controls.
Electric Arc Furnace (EAF) Steelmaking Facilities (under Area Source Program)	Part 63, Subpart YYYYY published in December 28, 2007 FR (72 FR 248)	Control of mercury emissions based on MACT standards and P2 requirements that scrap melted from motor vehicles must only be obtained from scrap providers participating in an EPA-approved program removing mercury switches (e.g., NVMSRP). Facilities must keep records identifying each scrap provider and documentation of scrap provider's participation in EPA-approved mercury switch removal program. Certification and documentation also required for scrap not containing motor vehicle scrap.	EPA estimates a mercury emission reduction of 5 tpy; PM by 865 tpy.	2	Existing facilities must meet compliance by 6/30/08; those that need to upgrade to meet opacity limit must comply by 12/28/10.
Iron and Steel Foundries – (Major Sources)	Part 63, Subpart EEEEE	Control of mercury emissions based on MACT standards and a work practice standard that includes a materials acquisition program specifying that the scrap supplier remove accessible mercury switches from the trunks and hoods of any automotive bodies contained in the scrap. Must obtain/maintain on-site a copy of the procedures used by the scrap supplier for either removing accessible mercury switches or for purchasing automobile bodies that have had mercury switches removed, as applicable.	Estimated nationwide reduction of 1.4 tons, from 1.75 to 0.35 tons	~ 40	Compliance with work practice standards for existing sources required by 4/22/05
Iron and Steel Foundries – (under Area Source Program for large and small foundries)	Part 63, Subpart ZZZZZ published in January 2, 2008 FR (73 FR 226)	Control of mercury emissions based on GACT standards, P2 and management practices for each subcategory (Small and large area source foundries). P2 requires scrap melted from motor vehicles must only be obtained from scrap providers participating in an EPA-approved program removing mercury switches (e.g., NVMSRP). Facilities must keep records identifying each scrap provider and documentation of scrap provider's participation in EPA-approved mercury switch removal program. Certification and documentation also required for scrap not containing motor vehicle scrap.	EPA estimates a mercury emission reduction of 5 tpy; 13.7 tpy for HAP metal compounds; 380 tpy for PM, and 32 tpy for organic HAPs. There are ~ 427 national area source iron and steel foundries (83 large – 344 small).	~ 40	Notice of applicability by 5/1/08. All area source foundries must comply with mercury P2 standards by 1/4/10.

Acronyms: CFR = Code of Federal Regulation; EPA = Environmental Protection Agency; FR = federal register; HAP = hazardous air pollutant; MACT = maximum achievable control technology; ; MW/hr = megawatts per hour; NESHAP = National Emission Standard for Hazardous Air Pollutant; NSPS = New Source Performance Standard; NVMSRP = National Vehicle Mercury Switch Recovery Program; PM = particulate matter; tpy = tons per year

Concentration Acronyms: dscm = dry standard cubic meter; g/mg = grams per milligrams; lbs/MMBtu = pounds per million British Thermal Unit; lbs/yr = pounds per year; mg/dscm = milligrams per dry standard cubic meter; µg/dscm = micrograms per dry standard cubic meter

TABLE 3-3: FORTHCOMING FEDERAL STANDARDS FOR MERCURY REDUCTION

REGULATED FACILITIES	REGULATION CITATION	MERCURY LIMITS	OTHER MERCURY-RELATED PROVISIONS	FACILITIES IN MICHIGAN	OTHER COMMENTS
Hazardous Waste Incinerators	Proposed rule to 40 CFR Parts 63, 264, 265, 266, 270, and 271 in 69 FR 21198 (April 20, 2004)	Incinerators new – 8 µg/dscm; existing – 130 µg/dscm Cement kilns new – 35 µg/dscm; existing – 64 µg/dscm Lightweight aggregate kilns – new and existing - 67 µg/dscm	Cement kiln – 0.23 tons reduction (beyond current standard); Lightweight aggregate kiln – 8 lbs/yr	0	
Other area source standards that could reduce mercury emissions include industrial boilers, institutional/commercial boilers, sewage sludge incineration, other solid waste incinerators (human/animal cremation), primary copper, copper foundries, secondary nonferrous metals (especially secondary zinc production, which uses EAF flue dust), ferroalloys production, and secondary inorganic chemical manufacturing (specifically mercury retorting).					

Acronyms: CFR = Code of Federal Regulation; FR = Federal Register; lbs/yr = pounds per year; µg/dscm = micrograms per dry standard cubic meter.

3.1.2 STATE AIR PERMITTING PROGRAMS

Michigan utilizes its air quality regulatory programs to reduce mercury released from point sources through the air permitting process.[59] In 1994, the AQD implemented the air toxics rules to address the release of toxic air pollutants.[60] Any new or modified source of mercury emissions must go through a best available control technology (BACT) for toxics review (commonly called T-BACT), these rules do not apply to existing sources. New or modified sources are required to demonstrate the maximum degree of mercury emission reduction reasonably achievable taking into account energy, environmental, economic impacts, and other costs. New or modified sources of mercury emissions must also go through a health-based screening review that uses modeling of source emissions to predict the ambient impact of a toxic chemical. Predicted ambient impacts can be no greater than health-based screening levels. Typically, these screening levels only consider exposure from direct inhalation. Because the primary concern for mercury is from indirect exposure pathways (i.e., consumption of fish), the health-based inhalation screening level of 0.3 $\mu g/m^3$ (with a 24-hour averaging time) was withdrawn and emissions of mercury are evaluated on a case-by-case basis. Therefore, mercury emission limits for new and modified sources are primarily set on a case-by-case basis. This evaluation considers not only the magnitude of emissions but also the proximity of inland lakes to the source. Because of this, mercury emissions do not qualify for an exemption from a permit to install under AQD Rule 290 (NREPA). There is a need for certainty in guidelines or rules that provide details for compliance for existing and new or modified sources that emit mercury. While agreements have been made to reduce or eliminate mercury from atmospheric sources, there are no comprehensive rules in Michigan that exist to guide the state when permitting facilities release mercury. The case-by-case reviews that have become routine for mercury sources often lead to uncertainty, inconsistency, and confusion. A clear, concise rule that provides guidance on what protocol the AQD should follow when reviewing mercury source air permits, would greatly improve the permitting process, modeling, and toxicological review for the state of Michigan.

[59] AQD permitting guidance at http://www.deq.state.mi.us/documents/deq-ess-caap-airpermittechmanual-Tab16.PDF.

[60] More on Michigan's Air Toxic Regulations are available at http://www.deq.state.mi.us/documents/deq-ess-caap-airpermittechmanual-Tab06.PDF.

The MDEQ has developed stricter standards for medical waste incinerators because documented mercury stack test data have demonstrated that with the application of mercury controls and a mercury waste management plan, facilities can easily meet an emission limit much lower than the federal standard (NREPA, R 336.1933). The AQD has also included mercury education outreach and collection of mercury-containing wastes as part of a permit requirement for a municipal waste combustor. Currently, the AQD is also considering seeking legislation on creating a five-year moratorium on new municipal and medical waste incinerators to limit annual emissions of mercury and eight other pollutants emitted by these facilities in Michigan. Benefits of this moratorium not only includes protecting the health of Michigan's citizens but will also positively impact the Great Lakes and neighboring states, and encourage innovations in waste disposal methods and P2 techniques.

Michigan auto shredders, as part of their permit conditions, must remove mercury switches prior to vehicle shredding. Sources that emit Hg(0) that include fluorescent light recyclers or autoclaves also have been required to install mercury controls. There should be consistency in the state for the control of all sources that use or process Hg(0). In addition, MDEQ is currently in the rule-making process for coal-fired EGUs and has formed a workgroup to examine potential emission reductions from cement kilns.

Another source of mercury that has not yet been adequately addressed is the removal of mercury-containing products during renovation and/or demolition activities. Asbestos, one of the first hazardous air pollutants regulated by EPA, like mercury, has been used in a wide range of manufactured goods. Currently, under Section 112 of the CAA, the AQD is responsible for enforcing the Asbestos NESHAP for the state of Michigan (NREPA, R 336.1942) and the WHMD regulates the disposal of asbestos. The Asbestos NESHAP protects the public by minimizing the release of asbestos fibers to the air during renovation and demolition activities. The AQD receives approximately 3,300 asbestos notifications each year.

In 2004, the MDEQ held a workshop titled, "*The Handling of Hazardous Building Materials: How to Stay Safe and Be Environmentally Friendly Workshop & Expo*" to help guide those who work in or near or manage a renovation or demolition activity to learn safe handling techniques involving asbestos, PCBs (polychlorinated biphenyls), fugitive dust, mercury, lead, and mold. Some of the mercury-containing products that should be removed prior to a demolition are thermostats, fluorescent lights, HID lamps, switches, batteries, etc. The MSWG recommends that rules need to be developed for removal of mercury-added products from buildings during renovation activities and prior to any demolition activities.

OTHER STATE AIR PROGRAMS

Numerous states have adopted state-only air regulations that apply specifically to mercury emissions (also discussed in **Chapter 5.4.1**). As of December 2007, there are approximately 24 states developing their own state rules that go beyond the CAMR for EGUs *(*see **Appendix O**). Several other states have rules that apply to other mercury sources and/or have adopted a general mercury rule for all sources. Note: The following are examples of several states that have developed mercury emission regulations (not an exhaustive list). There are other numerous regulations that address mercury in products, bans, labeling, etc.

MAINE has adopted a standard for mercury that limits air emission sources to 100 lbs/yr after 1/1/2000; 50 lbs/yr after 1/1/04, 35 lbs/yr by 2007 and 25 lbs/yr by 2010. An emission source may submit an application to the board for a license modification establishing an alternative emission limit for mercury. The board shall grant the license modification if the board finds that the proposed mercury emission limit meets the most stringent emission limitation that is achievable and compatible with that class of source, considering economic feasibility.[61]

NEW JERSEY requires 75% reduction from New Jersey's six iron and steel smelters by 1/2010 which is the largest source category in New Jersey. The emissions shall not exceed 35 mg per ton or 75% emissions reduction and each company must submit a mercury scrap minimization plan. For municipal waste combustors they have required a 95% reduction below 1990 levels by 2011 and emissions shall not exceed 28 microgram per dry standard cubic meter (µg/dscm) per four quarters or 80% reduction efficiency until 1/2006, 85% reduction after 1/2006, and 95% reduction on or after 1/2010. Hospital Medical Infectious Waste Incinerators in New Jersey must by 2006 not exceed 55 µg/dscm.[62] ***CONNECTICUT*** also adopted the 28 µg/dscm limit for municipal waste incinerators.

VIRGINIA has a *de minimus* standard for mercury of 2.9 lbs/yr for alkyl mercury compounds and 14.5 lbs/yr for other forms of mercury. These are based on a formula in their regulations which was derived from the time-weighted average and the ceiling recommended exposure limit (not to be exceeded at any time) from the American Conference of Governmental Industrial Hygienists (2006). They are also in the early stages of exploring a risk-based rule and are currently conducting a mercury modeling study to determine if additional regulations are needed to further control mercury from EGUs and/or regulations to control mercury from non-EGU sources (the study's final report is expected by October 2008). The following are Virginia's current and proposed rules addressing mercury:

- Article 4 - Toxic Pollutants from Existing Sources (Sections 200 to 270) effective January 1, 1985; last amendment: May 1, 2002.
- Article 5 - Toxic Pollutants from New and Modified Sources (Sections 300 to 370), effective January 1, 1985; last amendment: May 1, 2002.
- Part VI - Hg Budget Trading Program for Coal Fired Electric Steam Generating Units, effective April 4, 2007.
- Virginia has developed a state specific mercury budget trading rule for coal-fired EGUs and is waiting for EPA approval.

MINNESOTA has a significant number of rules that apply specifically to mercury that include a disposal ban of mercury-containing items into solid waste or wastewater systems along with specific goals for mercury release reductions, progress reports, and fluorescent light recycling facility permit requirements and mandatory fluorescent lamp collection programs by public utilities.[63]

WISCONSIN rules require facilities to report mercury emissions (and pay a fee) for their emissions if their annual emissions exceed 2.35 lbs/year for alkyl mercury compounds, 4.71 lbs/year for aryl mercury compounds and 5.88 lbs/year for inorganic mercury. If there are changes of over 10 lbs/year increase in mercury emissions, than the facility would require a BACT (for existing facilities).[64]

[61] Additional information for Maine's Bureau of Air Quality is at http://www.maine.gov/dep/air/.
[62] The New Jersey Division of Air Quality has information at http://www.nj.gov/dep/aqm/.
[63] Minnesota's Waste Management Act is at http://www.moea.state.mn.us/publications/wma-mercury.pdf.
[64] Wisconsin's Rule NR438 is at http://dnr.wi.gov/org/aw/air/emission/nr438/pollutants/pollutant_list.htm.

NEVADA has developed mercury specific air emission rules that apply to precious metal mining facilities.[65]

3.2 WATER

The federal CWA (Clean Water Act) sets the basic structure for regulating discharges of pollutants to waters of the U.S. and makes it unlawful for any person to discharge any pollutant from a point source into navigable waters unless a NPDES permit is obtained. The statute employs a variety of regulatory and nonregulatory tools to reduce direct pollutant discharges into waterways, finance municipal WWTP, and manage polluted runoff. These tools are employed to achieve the broader goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters so that they can support "the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water."

EPA delegates many permitting, administrative, and enforcement aspects of the CWA to state governments. Water quality standards (WQS), the foundation of the water quality-based control program mandated by the federal CWA,[66] define the goals for a waterbody by designating its uses, setting criteria to protect those uses, and establishing provisions to protect water quality from pollutants. The four basic elements of a WQS are:

1. **designated uses** of the waterbody (e.g., recreation, water supply, aquatic life, agriculture),
2. **water quality criteria** to protect designated uses (numeric pollutant concentrations and narrative requirements),
3. an **antidegradation policy** to maintain and protect existing uses and high quality waters, and
4. **general policies** addressing implementation issues (e.g., low flows, variances, mixing zones).

Each state has its own legal and administrative procedures for adopting a WQS. The Michigan WQS helps to identify water quality problems caused by, for example, improperly treated wastewater discharges, runoff or discharges from active or abandoned mining sites, sediment, fertilizers, and chemicals from agricultural areas, and erosion of stream banks caused by improper grazing practices (NREPA, Part 4).[67] The WQS also supports efforts to achieve and maintain protective water quality conditions, such as:

- TMDLs, waste load allocations for point sources of pollution, and load allocations for non point sources of pollution,
- water quality management plans which prescribe the regulatory, construction, and management activities necessary to meet the waterbody goals, and
- NPDES water quality-based effluent limitations (WQBELs) for point source discharges.

Michigan's WQS include specific numeric values for mercury in water which provide prescribed levels of protection for human health and wildlife. These values are 1.8 ng/L for human health protection (EPA, 1995b) and 1.3 ng/L for wildlife protection (EPA, 1995c). Derivation of the values assumes exposure of humans and wildlife to mercury through the aquatic system; the primary exposure pathway for both being fish consumption.

[65] Nevada's rules are at http://www.ndep.nv.gov/mercury/docs/nmcp_program_summary1105.pdf.
[66] Information on EPA's CWA is available at http://www.epa.gov/region5/water/cwa.htm.
[67] Michigan's WQS is available at http://www.deq.state.mi.us/documents/deq-wb-intreport-appendixa.pdf.

Michigan also uses a fish tissue value of 0.35 mg MeHg/kg (methylmercury per kilogram) as an indication of whether the human health water quality value is being met.[68] This value was derived using methodology similar to that used by the EPA to derive their value of 0.3 mg MeHg/kg (EPA, 2006d).[69] The main difference is that Michigan uses the exposure scenario for Great Lakes states established as part of the Great Lakes Initiative, whereas the EPA value is based on the exposure scenario for the entire U.S. Also, these values may be implemented differently as the MDEQ compares 0.35 ppm to the arithmetic mean of legal size fish of any single species, while EPA may take the average of fish from multiple species. Exposure scenarios for wildlife are much more complicated and a fish tissue value protective of wildlife is not yet available.

The fate and exposure of mercury in the aquatic environment is extremely complicated. New science is continually emerging related to the environmental conditions that affect conversion of inorganic mercury to MeHg (the form that most readily bioaccumulates), and the bioaccumulation of mercury. The MDEQ intends to review the mercury WQS in the future, in cooperation with the EPA and stakeholders, in light of current science to determine whether changes to the WQS are feasible and necessary.

The following chapters describe the programs in Michigan that regulate mercury in the state's surface water, groundwater, and drinking water.

3.2.1 SURFACE WATER

The EPA promulgated new Method 1631 on July 8, 1999, for measuring mercury in water that substantially increased measurement sensitivity.[70] The quantification level for Method 1631 is 0.5 ng/L, which is 400 times more sensitive than the previously used EPA Method 245.1. This is the first EPA promulgated method to enable the measurement of mercury at levels lower than Michigan's WQS for mercury (1.3 ng/L), which is based on the protection of wildlife.

The majority of ambient waters sampled for mercury, as well as most NPDES permitted discharges, were shown to exceed the WQS with the advent of the new Method 1631 (see detailed discussion below). To address this situation in NPDES permits, a multiple discharger variance was developed consistent with the requirements of R 323.1103(9) (the variance rule). Rule 1103 allows for a variance from a WQS that is the basis for a WQBEL in an NPDES permit where various conditions (e.g., naturally occurring or human-caused pollutant concentrations) prevent the attainment of WQS. Note that new dischargers do not qualify for the multiple discharger variance and are required to meet the mercury WQS.

MERCURY WATER DISCHARGE PERMITTING STRATEGY

The Mercury Permitting Strategy (Strategy), developed by the MDEQ's Water Bureau (WB) in February 2000, established a multiple discharger variance for mercury and outlined an approach for implementing Method 1631 in existing NPDES permits without causing widespread noncompliance with NPDES permit limits for mercury (MDEQ, 2004). This Strategy included a LCA of 30 ng/L, based primarily on effluent data from

[68] Michigan's fish tissue value was derived using the MeHg RfD and the WQS exposure factors – 65 kg [(0.1 µg/kg/day)(0.8)] / 0.015 kg fish/day = 0.35 mg/kg. Whereas 65 kg = female body weight; 0.1 µg/kg/day = RfD for MeHg; 0.8 = relative source contribution; and 0.015 kg fish/day = regional fish intake level.

[69] The EPA fish tissue value was derived using [70 kg (0.1 µg/kg/day – 0.027 µg/kg/day)] / 0.0175 kg fish/day. Whereas 70 kg = adult body weight; 0.1 µg/kg/day = RfD for MeHg; 0.027 µg/kg/day = relative source contribution (accounts for MeHg exposure via marine fish consumption); and 0.0175 kg fish/day = fish intake level for general population.

[70] The method was published as a revision of Title 40 of the CFR, Part 136, Guidelines Establishing Test Procedures for the Analysis of Pollutants, in the June 8, 1999, FR, Volume 64, No. 109, pp. 30417-30434.

the state of Maine, and a pollutant minimization program (PMP) requirement to continue efforts to meet the WQS of 1.3 ng/L for mercury. The LCA was established consistent with NREPA R 323.1103(6), which requires that the permit establish a WQBEL that represents a level achievable by the permittee, along with a PMP requiring the permittee to identify and eliminate sources of mercury in the discharge. A permittee is considered to be in compliance with the mercury limit if they do not exceed the LCA and are implementing the PMP. The Strategy provided permittees a period of time to switch from Method 245.1 to Method 1631, allowing for the development of laboratory capabilities and the collection of additional mercury data.

The MDEQ has updated its approach to implementing Method 1631 in NPDES permits for Fiscal Years 2005 to 2009. The goal of the 2004 Revised Mercury Permitting Strategy[71] is to move NPDES permitted discharges toward meeting the mercury WQS of 1.3 ng/L. Current effluent data continue to indicate that most point source discharges sampled using EPA Method 1631 do not meet the mercury WQS. Recent mercury data collected using Method 1631 under the February 2000 Strategy documents that mercury concentrations in most NPDES permitted discharges are significantly less than the 30 ng/L LCA. Therefore, the revised Strategy lowers the LCA to 10 ng/L. The revised Strategy will further the goal of attaining the mercury WQS through a reduced LCA and continued implementation of PMPs.

There are at least 45 individual NPDES permits that contain mercury limits and/or low-level monitoring requirements. Low-level mercury analyses continue to indicate that the level of mercury in many point source discharges can be expected to routinely exceed the WQS of 1.3 ng/L. Data obtained from compliance monitoring for point source discharges indicate that 42 out of 45 facilities with mercury limits or monitoring requirements have arithmetic mean mercury concentrations below 10 ng/L, with 35 facilities less than 5 ng/L.

TOTAL MAXIMUM DAILY LOADS

A TMDL is a tool for attaining Michigan's WQS. The objective of a TMDL is to allocate allowable contaminant loads among different pollutant sources so that the appropriate control actions can be taken and the Michigan WQS achieved. The TMDL determines the allowable contaminant loads and provides the basis for establishing or modifying controls on pollutant sources. After TMDL development is complete, TMDL implementation begins.

When sufficient water chemistry monitoring data are available indicating that a given waterbody is not meeting the Michigan WQS of 1.3 ng/L for mercury, or when sufficient samples of legal size species of fish from a waterbody are determined to average greater than 0.35 mg/kg for mercury, the waterbody is considered in nonattainment for mercury and is listed in the CWA Section 303(d) list (Edly and Wuycheck, 2006).[72]

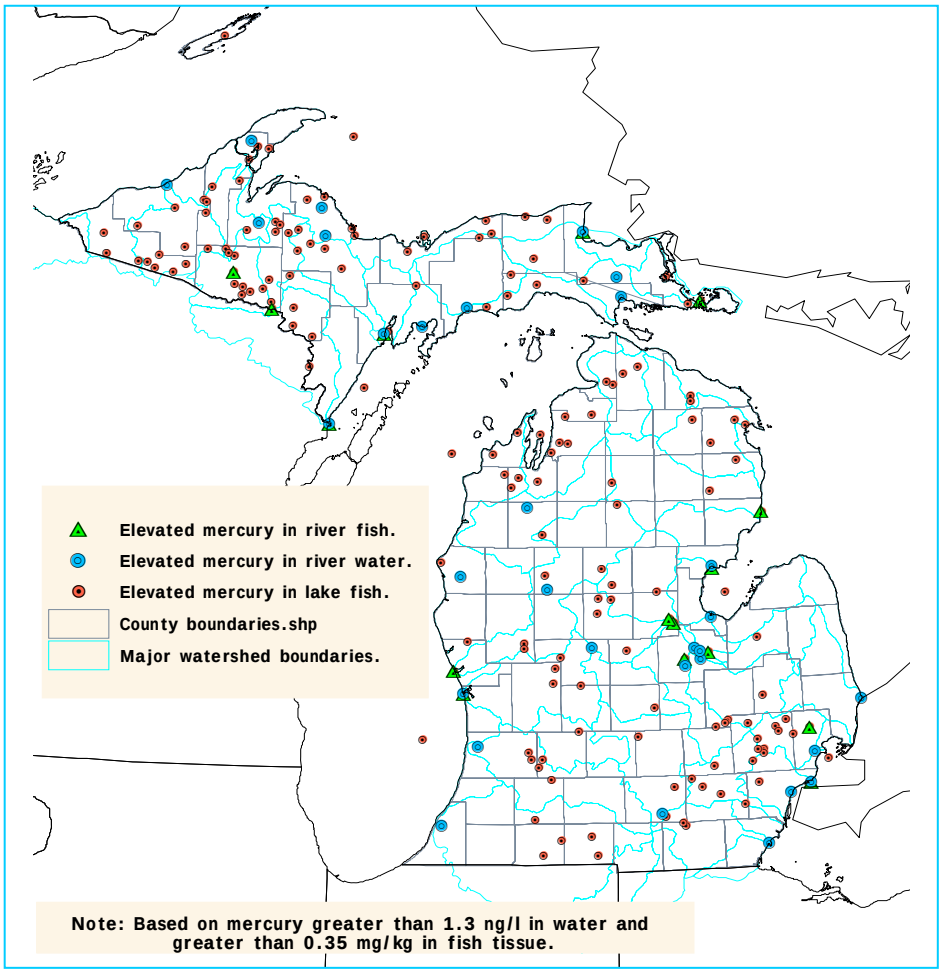
The 303(d) list identifies all nonattaining waterbodies and the contaminant(s) for which these waterbodies are in nonattainment, and identifies the date by which TMDLs must be developed for these waterbodies. The 303(d) list provides Michigan's supporting documentation required by 40 CFR, Section 130.7(b)(6), and rationale in fulfilling Section 303(d) requirements, and is submitted to the EPA in even-numbered years as part of Michigan's Integrated Report.

[71] The 2004 Revised Mercury Permitting Strategy is available at http://www.deq.state.mi.us/documents/deq-wd-mercury-permittingstrategy2004.pdf.

[72] The concentration of 0.35 mg/kg MeHg in fish is used by Michigan as an indicator of whether the standard for mercury in surface waters is being met. This value is not being used for fish consumption advisories.

The most recent 303(d) list was submitted by the MDEQ to the EPA in April 2006.[73] This list identifies 135 lakes and 478 river miles in nonattainment for mercury within Michigan (see **Figure 3-1**). A total of 171 mercury TMDLs are scheduled for completion by 2011.

FIGURE 3-1: WATERBODIES LISTED ON THE 303(d) LIST AS REQUIRING TMDLS FOR MERCURY



CLEAN WATER ACT'S 5M APPROACH

The EPA is providing information to states regarding a voluntary approach for listing waters impaired by mercury predominantly from atmospheric sources. Under this voluntary approach, those waters that are 90 to 95% impaired by atmospheric mercury can be placed within a subcategory (5m) of their federal CWA Section 303(d) list and the development of mercury TMDLs is deferred, if the state meets certain requirements. These requirements include that a state must have in place a comprehensive mercury reduction program with elements recommended by the EPA and the state should also demonstrate that it has begun to make some initial progress in reducing in-state mercury sources prior to placing waters in the subcategory 5m. A comprehensive program means that specific legislation, regulation, or other programs that implement the recommended elements have been formally adopted by the state, as opposed to being in the planning or development stage. The EPA does not expect that all of the activities or controls needed to carry out a specific program or regulation will have been

[73] The 2006 Water Quality and Pollution Control in Michigan: 2006 Sections 303(d) and 305(b) Integrated Report is available at http://www.deq.state.mi.us/documents/deq-wb-swqas-2006integratedreport.pdf .

fully implemented, or that the reductions expected from a program or regulation will have been fully achieved, before using subcategory 5m. However, the state's description of its mercury program and how the program meets the recommended elements should be included with its Section 303(d) lists. A state using the 5m subcategory may continue to defer the development of mercury TMDLs as long as the state is carrying out its mercury reduction program and demonstrates continuing progress in reducing in-state mercury sources.

The voluntary 5m subcategory acknowledges the complexity involved in developing TMDLs for waters impaired due to mercury from atmospheric mercury deposition. The 5m subcategory is not intended to delay action to address mercury impairments, but rather recognizes that a state is already taking other actions in advance of TMDLs to address its mercury sources. The 5m approach is designed to encourage early implementation of comprehensive mercury reduction programs, to recognize states for moving ahead to address their mercury sources, and to achieve environmental results sooner. This strategy would serve as the tool for implementing the 5m approach.

3.2.2 GROUNDWATER

The Groundwater Program regulates the discharge of wastewater to groundwater and the storage of hazardous materials under Part 31 of NREPA. The Administrative Rules governing discharges of waste or wastewater to groundwater are promulgated in the MAC at 323.2201 through 323.2241 under Part 22 Groundwater Quality. With respect to mercury, Rule 2222 5a sets the concentration in groundwater not to be exceeded as the concentration half way between the background groundwater quality and the concentration at which the site would be a facility as defined by Part 201.

3.2.3 DRINKING WATER

The MDEQ's WB has primary enforcement authority in Michigan for the Federal Safe Drinking Water Act under the legislative authority of the Michigan Safe Drinking Water Act. As such, the WB has regulatory oversight for all public water supplies, including approximately 1,500 community water supplies and 11,000 non-community water supplies. In addition, the program regulates drinking water well drilling. Michigan has more households (1.12 million) served by private wells than any other state, with approximately 25,000 domestic wells drilled per year. The MDEQ also investigates drinking water well contamination, and oversees remedial activities at sites of groundwater contamination affecting drinking water wells. The maximum contaminant level for mercury, as listed under the National Primary Drinking Water Regulations is 2 ppb.

3.3 SITES OF ENVIRONMENTAL CONTAMINATION

Mercury releases may have occurred from historical manufacturing operations in Michigan and may continue to leach to groundwater or surface water from historical manufacturing or disposal practices, or result from chemical or biological process involved in contaminant natural attenuation process. The MDEQ' RRD (Remediation and Redevelopment Division) administers programs that involve the cleanup and redevelopment of contaminated properties to achieve a healthier, cleaner, and more productive environment for Michigan's citizens. The primary legislative authority for the state cleanup program is Part 201, Environmental Remediation of the NREPA. Any area where contamination exists above the state clean-up criteria is a Part 201 facility. Releases of mercury from sites of environmental contamination are considered mercury legacy sites and are addressed by the State Clean-up Program (as

discussed in **Chapter 2.3**).[74] The following chapters discuss the soil and groundwater concentrations and standards that determine what is considered a 201 facility.

3.3.1 SOIL

Any area where contamination exists above the state clean-up criteria is a Part 201 facility. Releases of mercury from sites of environmental contamination are considered mercury legacy sites and are addressed by the State Clean-up Program (as discussed in **Chapter 2.3**). The statewide soil background concentration for mercury is 130 ppb. Concentrations at or below the statewide background value would not be a Part 201 facility. The mercury clean-up standards for soils that, if exceeded, would result in the area being a Part 201 facility are included in the following **Table3-4**.

TABLE 3-4: MERCURY SOIL CLEAN-UP STANDARDS

SOIL EXPOSURE	CLEAN-UP CRITERIA
Soils protective of drinking water	1700 ppb
Soils protective of groundwater venting to surface waters	100 ppb*
Soils protective of groundwater contact	46,000 ppb
Soils protective of vapor intrusion	48,000 ppb
Soils protective for volatile soil inhalation	52,000 ppb
Soils protective of particulate inhalation	20,000,000 ppb
Soils direct contact	16,000 ppb

*detection level

3.3.2 GROUNDWATER

The groundwater clean-up standards that, if exceeded, would result in the area being a Part 201 facility are included in the following **Table 3-5**.

TABLE 3-5: MERCURY GROUNDWATER CLEAN-UP STANDARDS

GROUNDWATER EXPOSURE	CLEAN-UP CRITERIA
Drinking water	2.0 ppb
Groundwater venting to surface water	1.3 ppt
Groundwater protective for vapor intrusion	56 ppb*
Groundwater contact	56 ppb*

*mercury water solubility limit

The process to address exceedances of clean-up standards includes decisions to mitigate risks (including remediation by persons responsible for causing the contamination) due care for non-causation liable owners or operators, baseline environmental assessments for liability protection, and disclosure of the general nature and extent of the release with any transfer of an interest in the property.[75]

3.4 WASTE

The MDEQ's WHMD administers a diverse number of prevention programs to protect the environment and the public's health through proper management of hazardous products; solid, liquid, medical, and hazardous waste; and radioactive materials. The following chapters describe the solid and hazardous waste programs that address mercury releases.

[74] Part 201, Environmental Contamination, of the NREPA. Part 213, Leaking Underground Storage Tanks, of the NREPA, uses the clean-up standards of Part 201.

[75] Baseline Environmental Assessment defines existing conditions and circumstances at a facility so in the event of a subsequent release, there is a means to distinguish new release from existing contamination.

3.4.1 SOLID WASTE

Michigan's solid waste requirements are found in Part 115 of the NREPA and the administrative rules promulgated thereunder. The solid waste program includes the review of construction permit and operating licenses for municipal and industrial non-hazardous solid waste disposal facilities including landfills, transfer stations and processing plants; inspection of those facilities to ensure compliance with operating requirements; management of the disposal area financial assurance program; administration of solid waste management planning and solid waste alternatives grants and loans. Mercury and mercury-containing items derived from households are regulated as solid waste. Therefore, they may be disposed in a facility authorized to accept solid waste.

INERTNESS

Part 115 of the NREPA does not regulate materials that are determined to be inert. Inertness designation requires an evaluation of contaminants that may endanger human health and the environment, including mercury.

ALTERNATE DAILY COVER

Part 115 requires six inches of soil to be applied to the working face of a solid waste landfill daily to control disease vectors, fires, blowing litter, and scavenging. The regulations allow the use of alternative materials as long as that use does not present a threat to human health and the environment.

The current guidance on alternate daily cover requires analytical testing for certain contaminants including mercury.[76] The maximum mercury concentration in alternate daily cover is 2,000 mg/kg, on a dry weight basis. This criteria is currently under review in an effort to update the assumptions used in development of the guidance.

3.4.2 HAZARDOUS WASTE

Control of hazardous wastes in Michigan is accomplished through a set of interrelated actions. These include managing the generation, treatment, storage and disposal of hazardous wastes, licensing and regulating hazardous and liquid industrial waste transportation, and informing individuals of the opportunities for proper disposal of hazardous and harmful wastes generated in the home.

Hazardous Waste in Michigan is regulated pursuant to Part 111 of the NREPA. The administrative rules promulgated pursuant to Part 111 of the NREPA include several direct references to mercury. These are summarized below.

TOXICITY CHARACTERISTIC

State and federal regulations define a waste as a toxic hazardous waste if the extract from a representative sample exceeds the regulatory standard of 0.2 mg/L using the TCLP (Method 1311). This standard is modeled upon the mobility of mercury from a waste disposed in a solid waste landfill and the potential for drinking water contamination.

LAND DISPOSAL RESTRICTIONS (LDR)

The hazardous waste regulations specify how hazardous wastes are managed and disposed under a program known as the LDR program.[77] The LDR program works specifically to minimize potential environmental threats resulting from land disposal of hazardous waste. The LDR program achieves this by establishing hazardous waste

[76] WHMD Operational Memo 115-10, Rev. 1, April 26, 1999, from Jim Sygo, Chief to all WHMD supervisors.
[77] Information on the LDR program is at http://www.epa.gov/epaoswer/hazwaste/ldr/index.htm.

treatment standards that make the waste safe for land disposal. The LDR regulations contain treatment standards for the Resource Conservation Recover Act of 1976 (RCRA) hazardous waste codes, including those identified as hazardous because of mercury. Hazardous waste may not be disposed until that waste meets the appropriate treatment standards. The LDR regulations categorize the following mercury wastes as low mercury wastes, high mercury wastes, or Hg(0) wastes.

Low Mercury Waste: Low mercury wastes are those hazardous wastes containing less than 260 mg/kg of total mercury. Current regulations require that these wastes be treated to a certain numerical level, i.e., 0.20 mg/L, measured using the TCLP for mercury residues from retorting, and 0.025 mg/L TCLP for all other low mercury wastes. These concentrations are generally met by stabilization/solidification treatment.

High Mercury Waste: High mercury wastes are those that are characteristically hazardous and that contain greater than 260 mg/kg total mercury. Because of this high concentration of mercury, they are generally required to undergo roasting or retorting defined, in part, as: "Retorting or roasting in a thermal processing unit capable of volatilizing mercury and subsequently condensing the volatilized mercury for recovery." The residuals from the roasting or retorting process are then subject to a numerical treatment standard (if the residues meet the definition of "low mercury subcategory").

Hg(0): Characteristic hazardous Hg(0) wastes (RCRA hazardous waste code D009) are required to be roasted or retorted, if they contain greater than or equal to 260 mg/kg total mercury. Because the uses for Hg(0) in products are declining, stockpiles of excess commodity (bulk) mercury currently exist. If these stockpiles are deemed to be wastes, then they are subject to the retorting or roasting standard. Waste streams of Hg(0) contaminated with radioactive materials are required to be treated by amalgamation, defined as: "Amalgamation of liquid, Hg(0) contaminated with radioactive materials utilizing inorganic agents such as copper, zinc, nickel, gold, and sulfur that results in a non-liquid, semisolid amalgam and thereby reducing potential emissions of Hg(0) vapors to the air."

Table 3-6 summarizes the treatment standards for mercury wastes by waste code utilizing the following definitions for IMERC and RMERC:[78]

- IMERC - Incineration of wastes containing organics and mercury in units operated in accordance with the technical operating requirements of 40 CFR Part 264, subpart O, and Part 265 subpart O.
- RMERC - Retorting or roasting in a thermal processing unit capable of volatilizing mercury and subsequently condensing the volatilized mercury for recovery.

[78] From EPA web site: URL: http://www.epa.gov/epaoswer/hazwaste/mercury/treatmnt.htm.

TABLE 3-6: LAND DISPOSAL RESTRICTION REGULATIONS FOR MERCURY-CONTAINING WASTE (NON-WASTEWATER)

MERCURY SUBCATEGORY DESCRIPTION	LDR TREATMENT REQUIREMENTS Concentration in mg/L TCLP or Technology Code	APPLICABLE WASTE CODES	FEDERAL REGISTER PUBLICATION
High Mercury-Organic Subcategory (i.e., the waste has a total mercury content greater than or equal to 260 mg/kg), contains organics, and is not an incinerator residue	Incineration (IMERC); OR Roasting or Retorting (RMERC)	D009 P092	55 FR 22569 (June 1, 1990)[b]
Mercury fulminate waste regardless of total mercury content and is not an incinerator or RMERC residue.	IMERC	P065	55 FR 22569 (June 1, 1990)[b]
Phenylmercury acetate waste regardless of total mercury content and is not an incinerator or RMERC residue.	IMERC OR RMERC	P092	55 FR 22569 (June 1, 1990)[b]
High Mercury-Inorganic Subcategory (i.e., the waste has a total mercury content greater than or equal to 260 mg/kg), and is inorganic, including residues from incineration, roasting and retorting.	RMERC	D009 K106 U151	55 FR 22569 (June 1, 1990)[b]
Low Mercury Subcategory (i.e., the waste has a total mercury content less than 260 mg/kg), and that are residues from RMERC only.	0.20 mg/L TCLP	D009[a] K071 K106 P065 P092 U151	55 FR 22569 (June 1, 1990)[b] K071 - 53 FR 31166 (August 17, 1988) D009 treatment standard revised 63 FR 28568 (May 26, 1998)
Low Mercury Subcategory (i.e., the waste has a total mercury content less than 260 mg/kg), and are not residues from RMERC.	0.025 mg/L TCLP	D009[a] K071 K106 P065 P092	55 FR 22569 (June 1, 1990)[b] K071- 53 FR 31166 (August 17, 1988) D009 treatment standard revised 63 FR 28568 (May 26, 1998)
Hg(0) contaminated with radioactive materials.	Amalgamation	D009 U151	55 FR 22569 (June 1, 1990)[b]
Hydraulic oil contaminated with Mercury Radioactive Materials Subcategory.	IMERC	D009	55 FR 22569 (June 1, 1990)[b]

The EPA recently published a Notice of Data Availability to make available to the public two studies conducted on treatment of mercury wastes. The studies were initiated to assess treatment and disposal alternatives to the current mercury retorting requirement. The EPA has concluded from these studies that a change in the LDR treatment standard for mercury is not warranted at this time. The notice also provides information on how to submit a petition for a site-specific variance from the treatment standards in the current LDR regulations.

COMPARABLE FUELS AND SYNTHESIS GAS

The state and federal hazardous waste regulations contain provisions to exclude certain materials that can be burned for energy recovery or used to produce synthesis gas from hazardous waste regulation. These provisions include specifications for contaminants including mercury. The mercury criteria is 0.25 mg Hg/kg (mercury per kilogram) of waste, at 10,000 British thermal units (Btu)/lb.

MONITORING REQUIREMENTS AND CORRECTIVE ACTIONS FOR RELEASE

The RCRA grants EPA and authorizes states to regulate hazardous waste management facilities that treat, store, or dispose of hazardous waste. Michigan is authorized to implement the corrective action portion of the RCRA under Part 111 of the NREPA.

Although the purpose of Part 111 requirement is to prevent toxic releases at hazardous waste facilities, accidents or other historic activities have resulted in releases of pollutants into soil, ground water, surface water and air. The RCRA Corrective Action Program, implemented pursuant to Part 111 of the NREPA, compels responsible parties to address the investigation and clean-up of hazardous releases. RCRA Corrective Action differs from Superfund in that Corrective Action sites generally have viable operators and on-going operations.

Because mercury is identified as a hazardous waste constituent, RCRA Corrective Action requires investigation and remediation of mercury. In Michigan, the Corrective Action Program uses the clean-up standards of Part 201 of the NREPA.

3.5 MDCH MERCURY REPORTING REQUIREMENT

In September 2005, the MDCH added to the MAC promulgated rules R 325.61 to R 325.68 - Heavy Metal and Pesticide Analysis Reporting requiring clinical laboratories to report all clinical test results of mercury in blood and urine, under the statutory authority of the Public Health Code. Like other public health surveillance systems, the system built on this reporting requirement includes collection of sufficient information about tested individuals and their health care providers to conduct follow-up to identify the source of exposure, which then triggers public health actions to mitigate exposures to others, if appropriate.

The reporting requirement, which also includes reporting of clinical test results for arsenic, cadmium, and cholinesterase, was established so that the MDCH could improve on the tracking and mitigation of human health impacts of environmental exposures to metals and cholinesterase-inhibiting pesticides.

In the first full year of reporting, 2006, the MDCH received over 4,500 clinical laboratory reports of mercury tests in blood and urine. About half of the tests did not find any detectable levels, and most of the rest were within the normal range. There were 475 samples of blood collected from women in the age range of 16-49 and 7% of these women exceeded the RfD assuming a 1:1 ratio of maternal to fetal blood. If a higher ratio of 2:1 in fetal to maternal blood is used than 13% of these woman exceed the RfD. There were 182 women in this age range for which urine samples were collected and 4% exceeded the World Health Organization level (see previous **Table 1-3**).

3.6 STATE LEGISLATION THAT LIMITS THE USE OR RELEASE OF MERCURY [79]

3.6.1 MERCURY IN SCHOOLS

PUBLIC ACT (PA) 376 OF 2000

According to PA 376 of 2000 (Enrolled Senate Bill 1262), Michigan's public and private K-12 schools were required to phase out and eliminate mercury use in the classroom and in the health (nurse's) office. This law applies to liquid (free flowing) Hg(0) as well as mercury-containing "instruments" such as thermometers, barometers, manometers, and sphygmomanometers (blood pressure gauges). K-12 schools had until December 31, 2004, to complete this process.

In addition, MDEQ developed a series of step by step instructions for completing this process titled "*Mercury Elimination Guidelines for Schools*" and incorporated it into a nationally award winning interactive CD (see **Chapter 4.2.8** for more information).[80]

3.6.2 THERMOMETER LAW

PA 578 OF 2002

PA 578 of 2002 (Enrolled House Bill 4599) requires that beginning on January 1, 2003, a person shall not sell, offer for sale, or offer for promotional purposes a mercury thermometer in this state or for use in this state. This subsection does not apply if the mercury thermometer is sold or offered for one of the following:

(a) A use for which a mercury thermometer is required by state or federal statute, regulation, or administrative rule.
(b) Pharmaceutical research purposes.
(c) By prescription. If this is the case, a manufacturer of mercury fever thermometers shall supply clear instructions on the careful handling of the thermometer to avoid breakage and proper clean up should a breakage occur with any mercury fever thermometer sold by prescription.

3.6.3 THERMOSTAT SALES BAN

PA 492 OF 2006

PA 492 of 2006 (formerly Senate Bill 124) bans the sale of thermostats that contain Hg(0) or a mercury compound beginning January 1, 2009. It does not apply if the thermostat is a replacement for an existing thermostat containing mercury or a mercury compound that is a component of an "appliance." The term "appliance" is precisely defined in PA 494. Thermostats that regulate home heating and cooling do not meet the definition of "appliances."

3.6.4 BLOOD PRESSURE DEVICE LAW

PA 493 OF 2006

PA 493 of 2006 (formerly Senate Bill 123) prohibits the sale of mercury-added blood pressure devices by January 1, 2008 and their 'use' by January 1, 2009, but for two exceptions; in home use and calibration of mercury-free devices in health care facilities, if deemed warranted.

[79] Mercury laws also at http://www.michigan.gov/deq/0,1607,7-135-3307_29693_4175-160230--,00.html.
[80] The publication is at http://www.deq.state.mi.us/documents/deq-ead-p2-mercury-mercinschools.pdf.

3.6.5 MERCURY-CONTAINING MEDICAL DEVICE(S) SALES BAN

PA 494 OF 2006

PA 494 of 2006 (formerly Senate Bill 186) bans the sale of esophageal dilators, bougie tubes and gastrointestinal tubes that contain mercury or mercury-compounds beginning January 1, 2009.

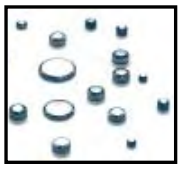
3.7 MICHIGAN MERCURY LEGISLATION RECOMMENDATIONS

In the 2003/04 and 2005/06 Michigan Legislative Sessions, nearly two dozen mercury reduction bills were introduced in each session. Primarily the bills were sales bans or mercury-containing product disposal bans and/or duplicate bills that were introduced by different sponsors in both the house and senate.

For coordination and continuity, it is important that the MDEQ continue to work closely with the Northeast Waste Management Official's Association (NEWMOA's) IMERC and the Michigan Legislature to ensure that proposed mercury legislation is consistent with the overall framework and general intentions of the Northeast Model Mercury Legislation (see **Chapter 3.7.1**) and does not unnecessarily conflict with legislation already enacted in other states. To accomplish this, t**he MSWG strongly recommends that the MDEQ become a full fledged, participating member of IMERC.** Membership would become even more important if product labeling and phase out exemption standards are to be eventually implemented in Michigan.

Some of the top priority mercury reduction legislation areas that MDEQ should immediately encourage and support include:

- **Ban the sale of mercury-added novelty products.** Novelty products should be defined as: A mercury-added product intended for use as a figurine, adornment, toy, game, card, ornament, yard statue or figure, candle, item of jewelry, holiday decoration, or item of apparel or any other similar mercury-added product intended mainly for personal or household enjoyment or adornment. A mercury-added novelty does not include games, toys or products merely because they require a button-cell or lithium battery.
- **Ban the sale of mercury-added button cell batteries.** After June 30, 2011, a person may not sell or offer to sell or distribute for promotional purposes a mercury-added button cell battery for consumer use or a product for consumer use that contains a mercury-added button cell battery. [81]



- **Require labeling of mercury-added products.** (see *Labeling* in **Chapter 3.7.1**).
- **Regulate the sale of Hg(0).** (See *Control the Sale of Hg(0)* in **Chapter 3.7.1**).
- **Require dentists** placing or removing dental mercury amalgam fillings **to install and properly operate a certified dental mercury amalgam separator that meets the International Standard Organization (ISO) 11143** achieving 97% or greater mercury amalgam removal from wastewater. Other approaches or technologies that completely isolate, capture, and treat dental mercury amalgam may be determined by the MDEQ as equivalent to having met this goal. Additionally, the legislation should require dental practices to use Best Management Practices (BMPs), which include proper operation and maintenance of this equipment, as well as provisions that require tracking of dental mercury amalgam waste.

[81] U.S. battery manufacturers have all voluntarily agreed to stop using (intentionally-added) mercury in button cell batteries by 2011 (QSC, 2006).

- **Phase out the sale of mercury-containing electrical switches, relays, and control devices.** This requirement should include mercury devices sold individually or as a product component, and should include a mechanism for review to grant an exemption (possibly through IMERC) to allow for use of a mercury device in instances where a suitable alternative is not available or when replacement components are needed to service existing equipment.
- **Phase out the sale of mercury-containing barometers and manometers.**
- **Ban the sale and use of mercury-containing manometers in dairy farming operations.**

The above recommendations represent the first phase of mercury product reduction legislation that could be pursued immediately. A second series of legislation that should come under serious consideration after 2010 would include such measures as:

- **Require mandatory collection and recycling of mercury-containing thermostats.** With the recent (April 2007) nationwide announcement of the expansion of the Thermostat Recycling Corporation (TRC) program, the MDEQ recommends that this voluntary recycling infrastructure be allowed to grow and expand in Michigan. Later, if warranted, mandatory measures could be employed, such as disposal bans, recycling take back requirements, or other types of mandatory measures. For now, it is important that the opportunity to conveniently recycle mercury devices, such as thermostats be established.
- **Ban the incinerator disposal of labeled mercury-added products.** Labeling law requirements should precede this legislation so that consumers readily know if the product they are discarding contains mercury, which would require special disposal. In addition, as previously stated, an adequate infrastructure for mercury product recycling/disposal should be established and supported so that everyone has reasonably convenient opportunities to properly dispose of mercury-containing devices before mandatory requirements take effect. Eventually the disposal ban on labeled mercury-added products could be extended to landfill disposal as well.
- **Require the recycling of all mercury-containing lamps.** This could be accomplished through promulgating or modifying existing administrative rules (i.e. require recycling of all mercury-containing lamps regardless of hazardous waste generator status or TCLP testing, enact legislation mandating manufacturer take-back, deposit, and/or disposal bans, etc.) The MDEQ recommends, as stated previously, that a voluntary recycling infrastructure needs to be developed and resources dedicated to this effort. Later, if deemed necessary, mandatory measures could be enacted.
- **Continue mercury product phase-outs.** Over a period of time (five to eight years) gradually phase-out remaining mercury-added products starting with those products that contain more than 1 g of mercury down to those that contain 10 mg.

In addition to this list of legislative recommendations, the MDEQ MSWG should continue to monitor mercury legislation enacted in other states and periodically evaluate possible future applications for Michigan.

3.7.1 MODEL MERCURY LEGISLATION

The Conference of NEG/ECP Mercury Action Plan included a recommendation to draft model legislation implementing coordinated labeling and manufacturer take-back programs to help consumers identify products containing mercury and how to properly dispose of them. In response to this and other Mercury Task Force recommendations, the NEWMOA developed the Mercury Education and Reduction Model Act in 1999.

NEWMOA MERCURY EDUCATION AND REDUCTION MODEL LEGISLATION

The legislative elements in the model reflect current efforts in the U.S. and Canada to reduce mercury in waste streams. It was put forth with the understanding that each state or jurisdiction would not necessarily implement all of the identified recommendations, together or at the same time. The model legislation is designed to be a flexible set of concepts from which states can choose those elements that meet their particular priorities. Many of these concepts have already been utilized in legislation adopted in northeastern states. Following is a summary of key components of the NEWMOA Mercury Education and Reduction Model Legislation:

NOTIFICATION: Require manufacturers and wholesalers to inform the state of the mercury-added products they sell and specify the type of product, name and address of manufacturer, amount of mercury in each unit, and total amount of mercury in all of the mercury-added products produced by the manufacturer.

INTERSTATE CLEARINGHOUSE: Establish a clearinghouse to coordinate key elements of the model legislation, including manufacturers' product notifications, applications for phase-out exemptions, collection plan reviews, applications for alternative labeling, mercury content disclosures, and public education and outreach.

BAN CERTAIN MERCURY-ADDED PRODUCTS: Ban the sale of mercury-added toys, games, cards, ornaments, apparel, and novelties in the state. Restrict the sale of mercury fever thermometers allowing consumers to purchase them with a prescription. Require manufacturers of mercury fever thermometers to include instructions on the careful handling, disposal, and clean-up of the thermometers sold through prescriptions. Ban the sale of dairy manometers in the state and authorize the state to establish collection and exchange programs for these products. Prohibit primary or secondary schools from using or purchasing Hg(0) or mercury compounds in the classroom.

PHASE-OUT AND EXEMPTIONS: Gradually phase-out mercury-added products starting with those products that contain more than 1 g of mercury down to those that contain 10 mg over a period of time.

LABELING: Require mercury-added products, components, and packaging to have a label. At a minimum labels would inform the purchaser that the product contains mercury and requires proper management practices; be clearly visible; and be sufficiently durable to remain legible.

DISPOSAL BANS: Prohibit mercury-added products from disposal as solid waste or in wastewater treatment facilities, unless allowed under a permit or license. Such products can only be accepted at state permitted or otherwise approved household hazardous waste (HHW) facilities, recycling facilities, or permitted hazardous waste facilities. This would also require separation of mercury components by scrap metal processing facilities.

COLLECTION: Require that manufacturers develop a plan and ensure the implementation of a system for the collection of mercury-added products through whatever mechanisms they choose. Manufacturers would submit a collection plan to the state that covers the jurisdiction. Legislation designates key elements of the plan. Also requires manufacturers to periodically report on the success of the collection system.

DISCLOSURE REQUIREMENTS FOR CERTAIN PRODUCTS THAT ARE USED BY HEALTH CARE FACILITIES AND CONTAIN INCIDENTAL MERCURY: Require manufacturers of specified formulated product categories that are used in health care facilities to disclose the mercury content of tested batches of their formulated product. These formulated products include acids; alkalies; bleach; materials used for cleaning, maintenance and disinfection; pharmaceutical products; stains; reagents; preservatives; fixatives; buffers; and dyes. This would apply to the formulated products in those categories that contain incidental amounts of mercury above 1 ppb.

CONTROL THE SALE OF HG(0): Restrict the sale of Hg(0) (liquid elemental mercury) except for limited medical, dental amalgam or research applications and require that safety information, including spill clean-up instructions, emergency contacts and a Material Safety Data Sheet accompany the mercury.

PUBLIC EDUCATION AND OUTREACH: Implement educational and outreach programs to support the implementation of the program elements outlined above. Establish an awards program. Require state to develop BMPs guidance for dental offices and laboratories to assist them with compliance with the disposal ban.

UNIVERSAL WASTE RULE: Require state to adopt Universal Waste Rules for largest number of mercury-added products and Hg(0) that is not contained in a product. Promote regional cooperation in development and implementation of these rules.

STATE PROCUREMENT: Implement a state procurement initiative that would allow for state contracts for goods and services to explicitly include a preference for low or non-mercury-added products which have comparable performance to mercury-added products. State contracts for dental services for state employees should provide equal coverage benefits for mercury-free fillings or restorations at no additional expense to the employee.

3.7.2 INTERSTATE MERCURY EDUCATION AND REDUCTION CLEARINGHOUSE (IMERC)

One of the key components under the NEWMOA's model legislation described above was the establishment of an interstate clearinghouse. In 2001, the states of Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont created the IMERC to help them implement laws and programs aimed at getting mercury out of consumer products, the waste stream, and the environment.[82] The states of Washington and Illinois joined in 2003 and 2004, respectively, and from 2005-2006 the states of California, Minnesota, and North Carolina also became participants. As a member of IMERC, a program of the NEWMOA provides:

- ongoing technical and programmatic assistance to states that have enacted mercury education and reduction legislation; and
- a single point of contact for industry and the public for information on mercury-added products and member states' mercury education and reduction programs.

NEWMOA's staff provides facilitation, logistical, and technical support for the activities of IMERC. IMERC facilitates deliberations that provide advice and assistance to the

[82] For more information, visit the IMERC webpage at www.newmoa.org/prevention/mercury/imerc.

individual states in their decision-making process. A state agency can benefit from participation in IMERC by:

- Consistency in state implementation of mercury education and reduction laws, including notification and other data gathering activities, phase-outs, labeling, and collection systems;
- Effective measurement of the impacts of the mercury-reduction programs;
- collecting and managing data on mercury-added products;
- making information on mercury-added products available to industry and the public;
- responding to requests for information on mercury management, education, and reduction legislation and other activities; and
- providing technical assistance, facilitating review, and making recommendations to the member states concerning (1) manufacturer notifications to states regarding the use, amount, and purpose of mercury in their products; (2) manufacturer applications for exemptions to the phase-out of mercury-added products; (3) manufacturer applications for alternative labeling of mercury-added products; and (4) manufacturer plans for collection and proper waste management of mercury-containing materials.

For all of the value-added services stated above, especially the elimination of redundancy when it comes to serving as a single point of contact for business, industry and government, it is recommended that Michigan join the IMERC.

4. MERCURY POLLUTION PREVENTION (P2)

Numerous mercury P2 activities have taken place throughout Michigan over the past 15 years. These include measures that typically lessen the volume or toxicity of mercury waste, as well as the application of source reduction techniques resulting in the use of fewer mercury products and, hence, less potential for mercury releases to the environment. To date, probably the most effective P2 technique has been 'product substitution,' where mercury-containing devices or products are replaced by safe mercury-free alternatives.

The MDEQ has a long-standing goal to identify and reduce the use and release of anthropogenic sources of mercury to the environment. The MDEQ's Environmental Science and Services Division (ESSD) has taken the lead for furthering mercury reduction through P2 by developing education/outreach materials and effectively administering mercury reduction programs. The ESSD also provides a valuable support function by helping other divisions integrate P2 into permits and Supplemental Environmental Projects (SEPs).

In the future, it is forecast that P2 will continue to play an integral role in any successful formula for the reduction of mercury entering Michigan's environment. Progress will be measured, evaluated and reported.[83] To date, mercury has been substantially reduced from 10 key sectors (see **Chapter 4.2**). Additional opportunities exist to significantly impact new areas and for MDEQ to partner with new stakeholders, including the shipping industry, veterinary clinics, as well as expanding efforts to target particular segments of the health care community, including but not limited to further advancements in the dental community.

MERCURY P2 MISSION STATEMENT

The mission of the Mercury Reduction Initiative is to reduce anthropogenic releases of mercury to the environment through the promotion of P2 activities. Reduction will be achieved through:

- Support the collection and safe and secure disposal of recovered mercury and mercury-containing devices.
- Promote awareness of alternatives, such as non-mercury-containing devices and mercury substitutes.
- Provide education and training on the environmental hazards of mercury.
- Provide education and training on proper handling.
- Find ways to eliminate mercury from mercury manometers, thermometers, auto switches, electric utilities, thermostats, hospital waste and healthcare uses, schools, and veterinary sources.

4.1 BACKGROUND

P2 has been a primary strategy for reducing mercury from Michigan's waste stream since the early 1990's. In December 1993, a *Michigan Mercury Action Plan* was developed by the MDEQ, MDCH, and the MPSC calling for the formation of the M2P2 Task Force. This collaborative, multi-stakeholder, interdisciplinary group began meeting in 1994; and in their 1996 final report, made over 70 mercury reduction recommendations. These recommendations were subsequently endorsed by Governor John Engler. They emphasized public education as the cornerstone for changing consumer behavior and business operating practices. To guide and track implementation of the M2P2 Task Force recommendations, the MDEQ developed an *M2P2 Task Force Implementation Strategy*, which was signed by MDEQ Director Russell J. Harding in February 1998.[84]

[83] Accomplishments are on the MDEQ's Mercury P2 website at http://www.michigan.gov/deqmercury/P2.
[84] The M2P2 Report is at http://www.deq.state.mi.us/documents/deq-ead-p2-mercury-mercstrat97.pdf.

4.2 P2 ACCOMPLISHMENTS

The MDEQ P2 accomplishments are divided in the following categories. Special emphasis is given to the first 10 sectors where the MDEQ has received project reports or has been able to document quantifiable mercury reductions. The chapters include:

- Dairy Farms
- Automotive
- Electric Utility Equipment Use
- Health Care
- Thermometers
- Dental
- Michigan Groundwater Stewardship Clean Sweep Program
- Schools
- Detroit Mercury Task Force
- Mercury SEPs
- Mercury Publications
- Regional, National and International Mercury Reduction Initiatives
- Emerging Sources of Mercury Reduction
- MDEQ involvement in Workshops and Events

Additional sectors that have favorable potential for further reductions are addressed at the end of this chapter with accomplishments summarized (reported to date) and future estimated reductions through 2010.

4.2.1 DAIRY FARMS

A dairy farm mercury manometer exchange program was piloted in 1998 and expanded statewide in 2000. Manometers are used to measure the suction pressure on the dairy milking machinery. The exchange program was co-sponsored by the MDA and the MDEQ. It offered dairy farmers up to $250 credit toward the cost of replacing mercury manometers with mercury-free vacuum gauges. In all, the project replaced 131 mercury manometers and collected 158 lbs of liquid Hg(0).[85]

4.2.2 MERCURY AUTOMOTIVE SWITCHES

It is noteworthy to acknowledge that the M2P2 Task Force was the first group in the nation to focus national attention on the auto industry's use of mercury. Their queries to automobile manufacturers coupled with MDEQ staff involvement, brought about the development of a Society of Automotive Engineers (SAE) White Paper study entitled: "*Mercury in Automotive Systems*" (SAE, 1996). This 'investigation' revealed the use of 9.8 metric tons of Hg(0) each year by the automotive industry in the production of mercury switches used in light trucks and automobiles. These mercury 'tilt' switches are located in assemblies found under the hood or deck lid (trunk) of vehicles and are used to control compartment lighting (shown at right). Mercury switches were also used to a somewhat lesser extent in some anti-lock braking G-force sensor devices.

Convenience lighting applications comprised the majority (> 85%) of the mercury used in vehicles. The M2P2 efforts called for the phase out of mercury use. By the 2003

[85] Further details about the mercury manometer replacement program are at http://www.mi.gov/mda.

model year, the automobile industry had voluntary ceased using mercury-containing switches in the production of vehicles.

The MDEQ also engaged in a number of projects to address removal of mercury switches from the existing automotive fleet. The MDEQ worked with the Alliance of Automobile Manufacturers (Alliance) and the SAE to develop and distribute a mercury-containing switch removal procedure (SAE, 1998). The MDEQ also participated with the Automotive Recyclers of Michigan (ARM) and the Kalamazoo Business Assistance Program on a statewide pilot project to remove mercury switches from scrapped vehicles at salvage yards. A total of 3,000 mercury switches were collected from the ARM members (2000-2001), resulting in 6 lbs of mercury removed from the automotive waste stream. The final evaluation of the pilot study by ARM showed that only about 25% of its members were willing to remove the mercury switches from salvaged vehicles during the pilot.

Later that year, the MDEQ and the Alliance began a study on the technical, logistical, and economic factors associated with removing mercury switches from end-of-life vehicles (ELV).[86] The MDEQ and Alliance also examined in-service switch removal and concluded that although beneficial, end-of-life switch verification and removal made the most sense from a logistical and cost-effectiveness standpoint.[87]

The Ecology Center of Ann Arbor has estimated that 9,799 lbs of mercury is present in vehicles currently in use in Michigan. Assuming an approximate linear reduction occurs over a 15-year period as vehicles are salvaged, it can be calculated that approximately 653 lbs of mercury could be eliminated each year.

In August, 2004, MDEQ became the first state environmental agency in the country to enter into a cooperative voluntary agreement with the automobile manufacturers to conduct a statewide collection program for the recovery of mercury automotive switches from ELVs. The MDEQ signed a two-year Memorandum of Understanding (MOU) with the Alliance thereby establishing what is known as the Michigan Mercury Switch Sweep (M2S2) Program. The goal of this voluntary program is to effectively remove mercury switches from scrapped automobiles prior to smelting (recycling) the vehicle body steel. If switches are not removed, the mercury is volatilized during the steel recycling process and released to the environment.

Initially, the M2S2 Program recruited automotive recyclers and metal shredders, although anyone involved in processing ELVs or in servicing in-use vehicles is encouraged to participate. From 2001 to present, more than 60,000 mercury switches have been successfully removed from scrapped automobiles in Michigan resulting in 132 lbs of mercury removed from the environment.

On August 11, 2006, EPA announced a voluntary national program that will help reduce mercury air emissions by up to 75 tons over the next 15 years. The National Vehicle Mercury Switch Recovery Program (NVMSRP) is designed to remove mercury-containing light switches from scrap vehicles before the vehicles are flattened, shredded, and melted to make new steel.[88] Together with existing state mercury switch recovery efforts, this program will significantly reduce mercury air emissions from the fourth leading source of mercury in the U.S. and the fifth largest in Michigan - the furnaces used in steel making. The existing M2S2 Program has already begun taking

[86] Additional study details are at: http://www.michigan.gov/deq/0,1607,7-135-3307_29693_4175---,00.html.
[87] In-service switch removal information is available at http://www.deq.state.mi.us/documents/deq-ess-p2-mercury-InServiceReview.pdf.
[88] Information on the NVMSRP is at http://www.epa.gov/mercury/switch.htm.

the necessary steps to transition into the new voluntary NVMSRP, such as sending letters to all dismantlers/recyclers in the state and issuing a MDEQ press release announcing the transition. The national program is being administered by End of Life Vehicles Solutions Corporation which is a not-for-profit company created by the auto industry in part to help manage the collection and recycling programs for automotive mercury switches.[89] In June 2007, the NVMSRP celebrated the recovery of the first 1,000 lbs of mercury. Partners signing the MOU agreement establishing the new national program are:

- The American Iron and Steel Institute — www.steel.org
- The Steel Manufacturers Association — www.steelnet.org
- The Automotive Recyclers Association — www.a-r-a.org
- The Institute of Scrap Recycling Industries — www.isri.org
- The End of Life Vehicles Solutions Corporation — www.elvsolutions.org
- The Environmental Defense Fund— www.environmentaldefense.org
- The Ecology Center — www.ecocenter.org
- The Environmental Council of the States (ECOS) — www.ecos.org
- The EPA — www.epa.gov

The MDEQ continues to encourage and in some instances require the removal of mercury switches from ELVs through measures such as sponsoring stakeholder workshops, performing education/outreach during on-site inspections and by incorporating mandatory switch removal requirements in AQD air permits issued for new or expanded steel manufacturing facilities and shredders. The MSWG recommends that MDEQ continue these activities, as well as, evaluate and promote opportunities for switch recovery using other existing regulatory programs, such as the WB's Industrial Stormwater Permits issued to salvage yards.

Nationally, additional drivers are emerging, such as the P2 requirements in two recently released NESHAP's for Area Sources - Electric Arc Furnace Steelmaking Facilities and Iron and Steel Foundries (see **Table 3-2** in **Chapter 3.1.1**). MDEQ should continue its education/outreach to the auto recycling industry and closely monitor the national program success. Since the NVMSRP is formally a three-year commitment by the above mentioned stakeholders, evaluating its success and determining future 'next steps' will be an important role for all parties involved. Through it's involvement with ECOS, MDEQ should continue close involvement in monitoring and oversight of the national effort.

4.2.3 ELECTRIC UTILITY MERCURY EQUIPMENT PHASE OUTS

(Does not include emissions from combustion)

As a result of the previously mentioned M2P2 recommendations, two of Michigan's largest utilities, Detroit Edison and Consumers Energy, identified sources of Hg(0) used within their operations, including customer gas regulators, thermostats, thermometers, manometers, barometers, switches, relays, timers, gauges in various meters, and bulk mercury in bottles. After the initial inventories were concluded, these companies committed to phasing out the use of mercury over time as equipment is retired. Thus far, Detroit Edison has reported elimination of 2,745 lbs of mercury sources while Consumers Energy has eliminated 1,488 lbs or approximately 60% of the original 1996 inventory of 2,464 lbs of mercury from their facilities. Additionally, on their own initiative, the Lansing Board of Water and Light eliminated more than 450 lbs of mercury from their facilities between the years 2000 and 2005 (Michigan Mercury Electric Utility

[89] Additional information is at http://www.epa.gov/epaoswer/hazwaste/mercury/carswich.htm.

Workgroup, 2005). It is anticipated that the remaining Michigan utility companies will follow suit and a considerable amount of mercury will be phased out of use over the next several years.

4.2.4 HEALTH CARE

Michigan's health care community ranks in a distinct group among a handful of other states leading the nation in mercury reduction. Health care facilities, in particular hospitals, are actively involved in reducing mercury use within their operations. In August 1997, the MDEQ, the NWF and the Michigan Health and Hospital Association (MHA) kicked off a major voluntary mercury reduction program that challenged hospitals to take a mercury-free pledge. This request was sent to all Michigan hospitals in a joint MHA and MDEQ letter mailed on August 15, 1997. The program's outreach efforts have included technical assistance, conferences, and distribution of information on mercury-free alternatives including cost and use comparisons. To date, nearly 80 of Michigan's 176 hospitals have formally taken the pledge to become "virtually" mercury-free. Others have voluntarily adopted mercury elimination practices.

Today the MDEQ continues to be a major stakeholder in Michigan's Hospitals for a Healthy Environment (H2E) campaign.[90] In 1998, the American Hospital Association signed a MOU with EPA to make all hospitals "mercury-free" by 2005. This campaign included the elimination of mercury-containing devices such as thermometers, esophageal dilators, and sphygmomanometers (blood pressure devices) by incorporating mercury-free substitutes for these devices as well as fixatives, reagents and other chemical compounds known to contain mercury.

The MDEQ has sponsored/co-sponsored a total of 14 conferences, workshops, and seminars throughout Michigan addressing such topics as recycling, waste reduction, medical waste minimization, red bag waste minimization, mercury elimination, reusables versus disposables, environmentally preferred purchasing and other health care related P2 topics.

The MDEQ-ESSD Retired Engineer Technical Assistance Program (RETAP) has conducted 26 waste assessments for Michigan hospitals and generated comprehensive P2 reports and recommendations. These reports contain detailed analysis and suggestions that frequently result in the reduction of waste and save the facilities considerable energy and money. Even small changes in practices in large institutions can yield significant savings. In some instances, RETAP assessments have been used as justification for funding P2 improvements under the ESSD's P2 Loan Program and other grant or loan sources.

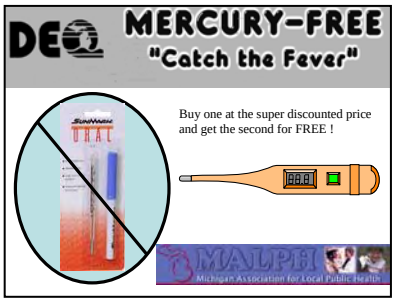
Nationally, more than 4,000 health care facilities in the U.S. have signed on to the Health Care Without Harm initiative to become mercury-free.[91] In 2006, 14 hospitals (five of these were Michigan hospitals) received Environmental Leadership Awards, the nation's highest environmental honor. From maintaining a phenomenal 46% recycling rate, to eliminating 5,000 lbs of waste by reprocessing single-use devices, to saving $200,000 by switching to energy efficient lighting, this year's Environmental Leadership Award winners are setting the highest standards of environmental performance in the health care industry. The following five Michigan hospitals were recognized nationally (more than one-third):[92]

[90] More on the H2E's campaign is at http://cms.h2e-online.org/ee/hazmat/reducing-hazardous-materials/.
[91] For additional Health Care Without Harm details, visit http://www.noharm.org/us/mercury/issue.
[92] For a complete list of award winners see http://www.h2e-online.org/awards/winners.cfm#MMMF.

- Borgess Medical Center, Kalamazoo
- Bronson Methodist Hospital, Kalamazoo (2003, 2004, 2005 winner)
- Sparrow Health System, Lansing (2005 winner)
- University of Michigan (U of M) Hospitals & Health Centers, Ann Arbor (2002, 2004, 2005 winner)
- W.A. Foote Health System, Jackson (2005 winner)

4.2.5 THERMOMETER EXCHANGES

In 1999, the MDEQ and the MDCH offered staff an opportunity to exchange their household mercury fever thermometers for digital models. This program was piloted to determine the efficacy of the exchange approach. Due to its success, this effort became known as the MDEQ's "Catch the Fever" Michigan Mercury Thermometer Exchange Program. The "Catch the Fever" Program provides incentives for the public to turn in their mercury thermometers as well as other mercury-containing devices they may possess. In addition to receiving a mercury–free digital thermometer, participants also receive educational brochures describing the dangers of mercury and an opportunity to speak with a mercury expert.



Later, MDEQ went on to secure federal grant funding from the EPA Great Lakes National Program Office (GLNPO) for statewide expansion of the "Catch the Fever" program. They then partnered with the MHA (1999-2001) and the Michigan Association for Local Public Health (MALPH) (2002-present) which eventually took over administrative responsibilities for day-to-day program operations.

Anyone is eligible to host a mercury thermometer exchange program.[93] Commonly, programs are hosted by municipalities, hospitals, health departments, schools, or businesses. Basically, the program sponsor or host buys one digital thermometer at a high volume discounted price and receives a second thermometer for free. Educational brochures are provided for public distribution at no cost, and the Michigan Groundwater Stewardship Clean Sweep Program is often chosen to dispose/recycle the mercury-containing devices that are recovered. This popular exchange program continues to grow since it provides a convenient, popular, and cost-effective method to retrieve and safely manage mercury-containing devices.

Thanks to the MHA/MALPH/MDEQ partnership, 81 exchanges have taken place and more than 40,000 mercury-containing devices, as well as 1,000 lbs of free-flowing liquid Hg(0) have been successfully recovered from medicine cabinets, basements, storage sheds, attics, and garages. In addition to thermometers, residents also turned in 'other' mercury-containing devices such as barometers, thermostats, manometers, flame sensors, esophageal dilators, and sphygmomanometers (blood pressure devices).

Perhaps even more importantly, thermometer exchanges have made citizens more aware about mercury and its potential dangers. These mercury P2 efforts have had a substantial impact on businesses too, as evidenced by the 14 major pharmacy retail chains that have voluntarily agreed to stop selling mercury fever thermometers across the country. Note: Effective January 1, 2003, it is illegal for anyone to sell a mercury thermometer in Michigan (see PA 578 of 2002 in **Chapter 3.6.2**).

[93] To host a thermometer exchange or for questions about upcoming thermometer exchange events taking place in their area should contact Julie Zdybel, MALPH at 517-485-0660, or visit http://www.malph.org.

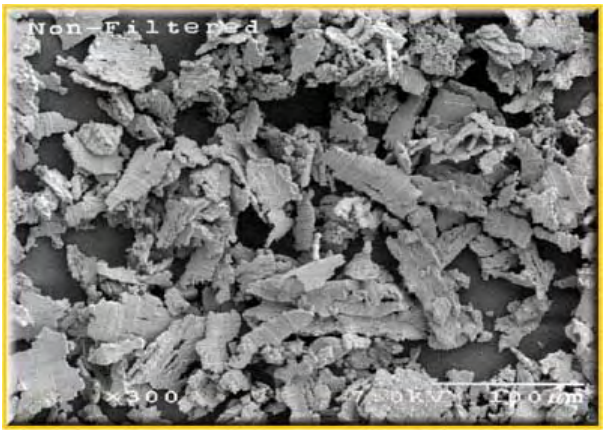
4.2.6 DENTAL

Beginning in December 1994, the Detroit Water and Sewerage Department (DWSD) formed a partnership with the NWF, the Michigan Dental Association, the Michigan United Conservation Clubs and the MDEQ to reduce mercury release to its facilities from dental offices in southeast Michigan. This effort originated as a PMP requirement of the DWSD's NPDES Permit (No. MI0022802). This group was called "DWSD's Task Force for Mercury Minimization From Dental Offices." This group in tern conducted a statewide clean sweep for mercury from dental offices. In 1996, this statewide bulk mercury dental collection program netted 1,400 lbs of Hg(0) from 400 dentists at 11 drop off sites established throughout Michigan. Today, the DWSD continues promoting mercury reduction efforts for dental facilities and distributes posters and brochures encouraging that BMPs be utilized at dental facilities.

Although early dental mercury minimization efforts first targeted DWSD's service area, which consists of the City of Detroit and 76 surrounding suburban municipalities, eventually the outreach was expanded statewide throughout Michigan, thanks to closely coordinated efforts with the M2P2 Task Force and their Dental Subgroup. During the following two and a half (2½) year period, a number of significant achievements took place which included an extensive dental amalgam literature review, conducting two surveys of the dental community (both before and after targeted education/outreach initiatives), development and distribution of a waste amalgam recycling procedures, and implementation of the afore mentioned statewide bulk mercury collection program. An example of mercury amalgam waste is shown in **Figure 4-1**.

Representatives from the dental group also worked to pass a Michigan Dental Association resolution calling for Michigan dentists to only use pre-capsulated amalgam alloy and to eliminate use of bulk dental mercury and bulk amalgam alloy. Pre-capsulated amalgam uses individually measured prescribed doses in direct proportion to the size of the specific restoration. This practice results in less spillage, less fumes, and less excess material left over after the procedure, thereby reducing waste and the risk of mercury exposure to dental personnel.

FIGURE 4-1: WASTE DENTAL MERCURY AMALGAM RESULTING FROM PLACING OR REMOVING RESTORATIONS



Mercury amalgam that enters a WWTP usually settles out in the sewage sludge, which eventually is either incinerated, heat treated, and/or land applied as bio-solids. When mercury amalgam is heated it volatilizes and is released to the atmosphere where it eventually enters the environment.

An additional concern occurs at dental practices where waste amalgam is disposed of improperly in the regulated medical waste 'red bag' containers. Eventually, this waste material is either incinerated or autoclaved where volatilization of mercury as a result of these processes can enter the environment. Another improper disposal practice is where filters or traps are cleaned and the contents rinsed either down the drain or thrown into the regular trash. For communities that incinerate their solid waste, this practice poses a potentially serious concern.

Because dental practices generate relatively small amounts of regulated hazardous waste, most small practices qualify to be classified as conditionally exempt small quantity generators and may legally dispose of dental mercury amalgam in their regular trash. Although legally permitted to do so, this practice is discouraged in BMP publications where the loophole is eliminated.

In the past there has been some uncertainty and debate in the scientific community as to the bio-availability of the mercury found in dental mercury amalgam. One recent study found that mercury from an environmental exposure representative of dental amalgam concentrations typically found within the dental wastewater discharge stream is bio-available to fish and may accumulate in internal tissues (Kennedy, 2003)

For all the reasons listed above, it is important that mercury amalgam be managed properly and be recycled. To ensure this occurs, a formal waste manifest or tracking system should be implemented. It should be noted that this recommendation was one of the M2P2 Task Force Recommendations but has yet to be implemented.[94] It does little good to filter, trap and remove dental mercury amalgam only to have it improperly disposed of and subsequently pose a risk to the environment. This is why recycling and waste tracking have become key components of dental BMPs. Manifests and records describing what happened to the mercury amalgam material should be retained on site at the dental practice for a period no less than three years.

Today, MDEQ continues to promote mercury amalgam recycling as an important component of dental BMPs and has worked closely with Michigan communities such as Manchester, Richmond, and Wyoming where use of amalgam separators have become a required operating practice for dental facilities under those communities' respective municipal PMPs. Amalgam separators are capable of efficiently removing more than 95% of the mercury amalgam generated in a dental practice. Numerous states now require amalgam separators (see **Chapter 4.4.2**)

The MDEQ authored a series of articles on dental amalgam waste management and BMPs which were published in the "*Journal of the Michigan Dental Association*" (Kratzer, 2003a; Kratzer, 2003b). More recently the American Dental Association and the EPA began collaboratively developing and promoting the "Gray Bag" dental amalgam recycling program along with other BMPs for dental facilities. Other states in the Great Lakes region and their respective local dental associations are also involved in promoting BMPs to dentists.

As the public becomes increasingly knowledgeable and concerned about health effects related to mercury, this issue has helped spawn research and shifted trends in technology toward mercury-free restorative materials, including gold, ultraviolet-cured composites, and gallium (another non-mercury alloy). Studies indicate gallium is similar to mercury amalgam in properties such as tensile strength, creep, hardness, and comprehensive strength. The American Dental Association's Paffenbarger Research Center has introduced (in 1999) a pure silver filling material that cold welds as it is condensed. These promising mercury-free materials are continuing to gain popularity and increased use within the dental community.

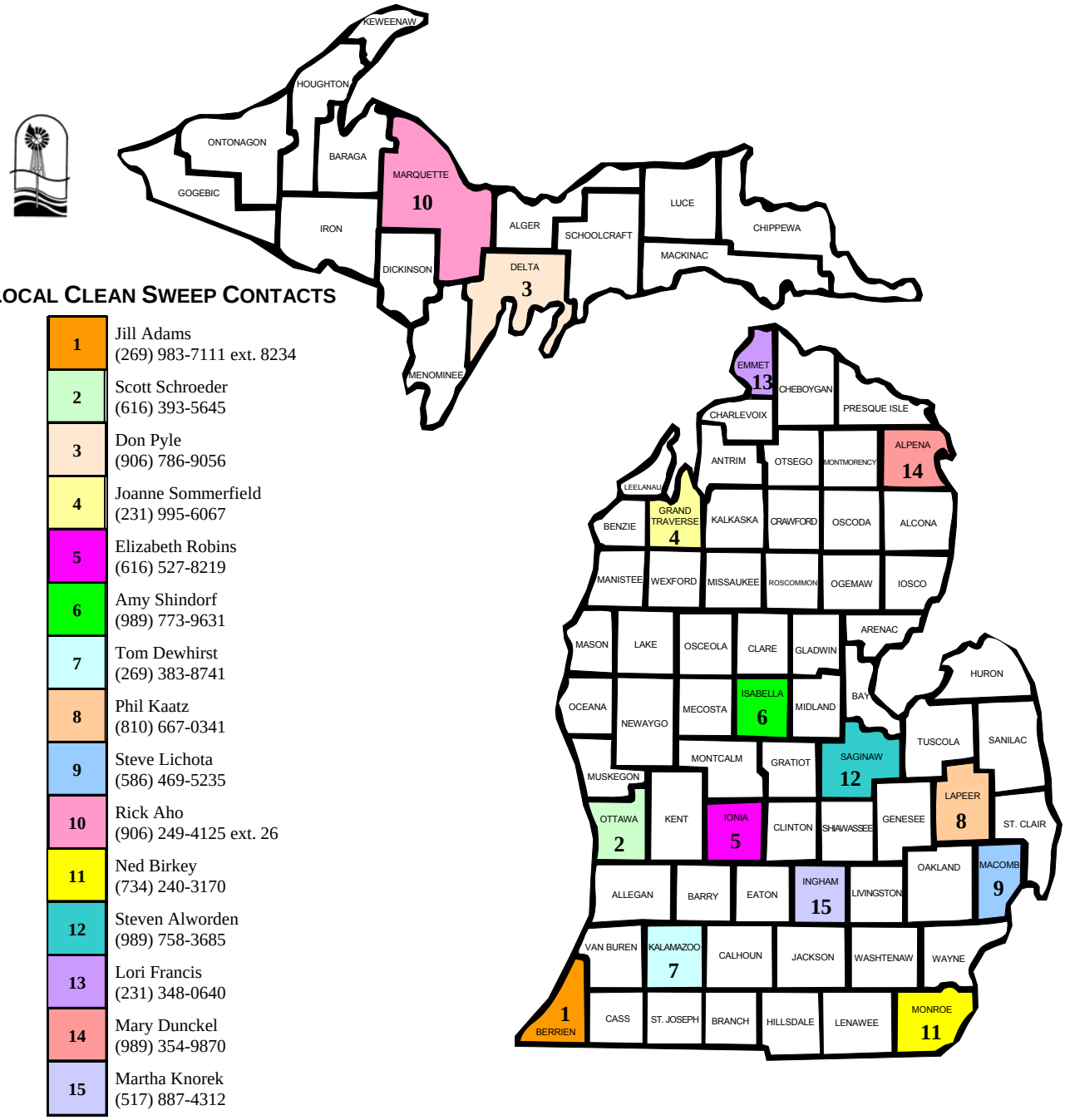
4.2.7 GROUNDWATER STEWARDSHIP 'CLEAN SWEEP' PROGRAM

The 'Clean Sweep' Program, administered by the MDA, has been in existence since 1987 (mobile sites) and 1996 (permanent sites). The Clean Sweep program provides

[94] This M2P2 recommendation can be found in April 1996 Mercury Pollution Prevention in Michigan, Final Report; Dental Subgroup Recommendation #6, page 36.

financial and technical support for 15 sites throughout Michigan and allows citizens the opportunity to bring in fertilizers and pesticides for proper disposal (see **Figure 4-2**). All Clean Sweep sites also function as HHW drop-off sites. As a result of mutual cooperation through the dairy manometer exchange project and through the encouragement of the MDEQ, the MDA has expanded the program to allow for the collection of mercury and mercury-containing devices.

FIGURE 4-2: MICHIGAN GROUNDWATER STEWARDSHIP PROGRAM CLEAN SWEEP - FREE MERCURY AND PESTICIDE DISPOSAL FOR RESIDENTS AND BUSINESSES



LOCAL CLEAN SWEEP CONTACTS

1	Jill Adams (269) 983-7111 ext. 8234
2	Scott Schroeder (616) 393-5645
3	Don Pyle (906) 786-9056
4	Joanne Sommerfield (231) 995-6067
5	Elizabeth Robins (616) 527-8219
6	Amy Shindorf (989) 773-9631
7	Tom Dewhirst (269) 383-8741
8	Phil Kaatz (810) 667-0341
9	Steve Lichota (586) 469-5235
10	Rick Aho (906) 249-4125 ext. 26
11	Ned Birkey (734) 240-3170
12	Steven Alworden (989) 758-3685
13	Lori Francis (231) 348-0640
14	Mary Dunckel (989) 354-9870
15	Martha Knorek (517) 887-4312

For the past several years, the MDEQ has provided financial support for the mercury recycling/disposal Clean Sweep initiative through grant funding provided by the EPA and, in one instance, a private donation. Schools, farms, hospitals, small businesses, and the general public were provided the opportunity to drop off liquid Hg(0) and mercury-containing devices 'free of charge' at any of Michigan's 15 Clean Sweep sites. Tales From a Clean Sweep Site is a powerpoint presentation that shows the types of mercury-containing devices that have been collected.[95] Since 1999, over 112,000 mercury-containing devices have been recovered. When mercury content of these devices are combined with the amount of liquid Hg(0) recovered, it represents about 10,000 lbs of mercury that have been successfully removed from Michigan store rooms, classrooms, basements, attics, closets and storage sheds. However, funding to support Michigan's Clean Sweep mercury collection and recovery efforts ran out September 30, 2006. To date, MDEQ has been unable to secure additional grants or commitments for continued funding, thereby placing the program in jeopardy.[96]

It should be noted that were it not for the Clean Sweep Program, much of the mercury referenced above may have wound up in landfills and municipal incinerators. In addition, countless accidents and potentially serious spill incidents have also been prevented thanks to this recovery effort. The Clean Sweep Program serves as a model for successful joint cooperative ventures between two state departments, as well as a cornerstone which has historically aided draft mercury legislation in Michigan to become law. For example, it provided citizens a place to dispose of mercury fever thermometers and a place where schools could take their mercury instruments, free of charge, advancing key pieces of mercury legislation (PA 578 of 2002 and PA 376 of 2000 discussed in **Chapter 3.6**). The future of additional mercury reduction legislation such as mercury-containing product disposal bans will continue to rely heavily on the Clean Sweep Program, as well as the other HHW waste collection facilities. The MSWG recommends that efforts to inform Michigan citizens about mercury drop-off collection opportunities should be expanded.

4.2.8 MERCURY ELIMINATION IN SCHOOLS

PA 376 of 2000 was signed by Governor Granholm on January 2, 2001 (see **Chapter 3.6.1**). Under this law, K-12 school officials (public or private) had until December 31, 2004, to ensure that they do not purchase, store, or use any Hg(0) or mercury-containing instruments. This law applies to liquid (free flowing) Hg(0), as well as mercury-containing instruments such as thermometers, barometers, manometers, and sphygmomanometers (blood pressure gauges).

The MDEQ orchestrated a series of activities to inform Michigan schools of their responsibility under this legislation. As part of this outreach effort, letters were sent to principals, science teachers, library/media specialists and superintendents on April 20, 2001, followed by a reminder letter on May 20, 2002. The first series of letters were co-signed by the Director of the MDEQ and the Superintendent of Public Instruction, MDE.

[95] The presentation is at http://www.deq.state.mi.us/documents/deq-ess-p2-mercury-ppt-dewhirst.pdf
[96] To locate a Clean Sweep site contact MDEQ's Environmental Assistance Center at 800-662-9278 or visit www.mi.gov/deqmercuryp2 - Select: "*Where to take mercury and mercury-containing devices*" and "*Mercury and Pesticides drop-off sites.*"

The ESSD also developed an eight-page fact sheet enclosure that accompanied the first letter titled "*Mercury Elimination Guidelines; Where to Find It and How to Eliminate It*." In the second round reminder, ESSD developed and inserted a nationally award winning (National P2 Roundtable) CD diskette titled "*Michigan Mercury Pollution Prevention: A compilation of resources about mercury, its dangers, and what to do with it.*"

Other outreach activities directed at Michigan's K-12 schools included MDEQ staffing of mercury reduction displays at the annual state science conference(s). Staff handed out posters, brochures, and fact sheets. As opportunities arose to get on the conference agenda, staff would also deliver mercury presentations.

In addition to the above conference outreach, MDEQ partnered with the MDCH, Detroit Medical Center, Wayne County Regional Educational Service Agency (RESA), and other interested entities to conduct a series of school mercury workshops throughout Michigan. In all, MDEQ participated in 25 separate events highlighting concerns over mercury and introducing audiences to the new school mercury legislation.

MERCURY-IN-SCHOOLS INTERVENTION (MISI) PROJECT

In 2005, despite all of the efforts listed previously, four reports of mercury spills in schools were received. As a result of this data, the MISI project was developed to collaborate with the MDE, MDCH, and the MDEQ to develop a public health approach to assuring that all Michigan K-12 schools are in compliance with the law. The MISI project involved:

- the development of a four-page guidance booklet on how to identify and dispose of mercury along with a cover letter that included a brief survey requesting schools to indicate the status of their mercury removal process. In July 2006, the cover letter, survey, and guidance booklet were mailed to 4,712 school principals and the 685 district school superintendents.
- coordinated efforts with the Center for Educational Performance and Information (CEPI), an office within the Office of the State Budget that collects and reports data every spring about Michigan's K-12 public schools, to facilitate school districts' compliance with the federal No Child Left Behind Act of 2001 and the MDE's accreditation requirements. In this effort, CEPI agreed to add a question about compliance with the mercury-in-schools law into their spring 2007 survey and to provide the MISI project with the results of the survey. Also included in the mailing was the MDEQ's Environmental Assistance hotline number as the primary source of technical assistance for the mercury removal process.

Results of the MISI project, as of January 25, 2007, include:

- 1750 (37.1%) of the schools returned completed surveys to MISI, with almost all reporting that the mercury removal process was complete;
- over 25 schools indicated on the survey or called MISI for assistance as they had not yet completed the process;
- the MDEQ also received calls for assistance; and
- the MDCH learned of nine mercury spills in schools since the letter was sent that included a spill at a school previously reported on a MDCH survey as being mercury-free.

The MISI project and the MDEQ will continue to provide assistance to schools that request help. The CEPI survey data will be available in late 2007 and MDCH staff will

follow-up with any additional schools still not in compliance.[97] All survey data will be analyzed and provided to the MDE, MDEQ, and others to determine the success of the law and these follow-up interventions for ensuring that children will not be exposed to mercury at school. The MSWG recommends that outreach needs to continue to schools to ensure all schools are in compliance and that a list of mercury-free schools should be posted on the MDEQ website.[98]

SCHOOL COLLECTION GRANTS

The MDEQ has participated in several school chemical cleanout collection events funded by EPA. These collections allowed schools to remove old, outdated and unwanted laboratory chemicals, including mercury compounds, Hg(0) and mercury-containing devices such as thermometers and manometers. **Figure 4-3** shows an example of a school's cupboard containing miscellaneous chemicals included a coffee can full of laboratory mercury thermometers (circled in red).

FIGURE 4-3: MERCURY THERMOMETERS FOUND IN SCHOOL

EPA FUNDED SCHOOL COLLECTIONS IN MICHIGAN: From 2004 to 2006, a total of 188 schools participated in removing 1,823 mercury-containing items, 293 lbs of mercury compounds, and 971 lbs of Hg(0). The following summarizes those efforts:

- Flint (2004): 62 schools, 845 mercury-containing items, 79 lbs of mercury compounds, 562 lbs of Hg(0).
- Benton Harbor (2004): 24 schools, 239 mercury-containing items, 18 lbs of mercury compounds, 90 lbs of Hg(0).
- Cadillac (2005): 26 schools, 354 mercury-containing items, 36 lbs of mercury compounds, 233 lbs of Hg(0).
- Saginaw (2006): 32 schools, 52 mercury-containing items, 40 lbs of mercury compounds, 20 lbs of Hg(0).
- West Michigan (2006): 44 schools, 333 mercury-containing items, 120 lbs of mercury compounds, 66 lbs of Hg(0) (as part of the West Michigan Children's Health Initiative.

2005/2006 COMMUNITY P2 SCHOOL CHEMICAL GRANTS: The 2005 and 2006 Community P2 School Chemical grants seek to address waste reduction of school chemicals by not only cleaning out excess, legacy, unused, and improperly stored chemicals; but by also going a step further and requiring the implementation of mechanisms for toxic chemical waste minimization.[99] The school grant recipients will be implementing various programs to support these goals that include creating chemical inventories and management plans, hazardous chemical disposal, and developing alternatives to storing chemicals on site. The remainder of the grant funds will be used for teacher training, curriculum development, new purchasing procedures to prevent new toxics, inventory software, and other P2 steps.

Practicing waste reduction and P2 in schools teaches environmental responsibility and helps instill an understanding of the risks of toxic chemicals. The ultimate goal

[97] For a listing of those schools and school districts who have responded as being mercury-free, visit http://www.michigan.gov/documents/mdch/mercuryfreeschools_198913_7.pdf and http://www.michigan.gov/documents/mdch/mercuryfreeschooldistricts_198915_7.pdf, respectively.
[98] Additional details about mercury in schools are available at http://www.mi.gov/deqmercuryinschools.
[99] Information on these P2 grants is at http://www.michigan.gov/deq/0,1607,7-135-3585-10949--,00.html.

of this grant is to create a chemically safer school environment in which chemicals are purchased wisely, stored safely, handled by trained personnel, used responsibly, and disposed of properly. It should not only remove stockpiles of dangerous and old chemicals, including mercury, but also prevent new, dangerous stockpiles from developing.

The Community P2 School grant recipients are required to match the state funds by at least 25%. The 2005/2006 grant provided 20 schools with funding of $440,419 and a total budget (grant and match) for clean outs at $147,446. Of the schools that have completed their chemical removal projects, over 7,700 lbs of materials and chemicals were removed. This included explosives, nuclear materials, and toxics such as an estimated 137 lbs of mercury in free metal form and as chemical compounds. In addition, at least 100 thermometers and other mercury equipment were removed. It is important to note that there may have been more mercury removed that has not been reported as some grants do not cover the disposal. In addition, about half of the schools will be continuing disposal efforts for about another year.

MERCURY IN GYMNASIUM FLOORS

Beginning in the 1960s and continuing through the 1980s synthetic gymnasium flooring and outdoors track surfaces that contained mercury compound as a catalyst were installed in schools throughout the country. State health departments in Ohio (2002), Michigan (2004) and Oregon (2006) have encountered and investigated these floors, particularly those manufactures by the 3M Corporation under the name of Tartan® floors and Tartan® track. The 3M Tartan Brand floor covering is a solid, rubber-like polymer floor covering developed in the 1960's and promoted as a substitute for and improvement over wood flooring in gymnasiums and as a durable running surface for both indoor and outdoor track and field facilities. According to 3M, mercury was used as a catalyst when mixing the polymer to form the floor covering resulting in a finished product typically containing 0.1 to 0.2% mercury.

The three state health department investigations raised concerns about on-going exposure to children in schools that contain these types of flooring materials and about procedures for removal of damaged flooring and appropriate disposal requirements. When floors are damaged, the surfaces give off Hg(0) vapor particularly concentrated in the damaged areas. However, air testing results in gymnasium settings varied greatly in concentrations of mercury vapor. For example, two floors screened in 2006 at the same school complex in Michigan showed a factor of four difference in vapor though they were installed only four years apart (1970 and 1974). Investigators do not currently understand the reasons why some floors are emitting an unacceptable amount of mercury vapor and some floors do not currently present a health hazard. Therefore, an investigation to identify the controlling factors of mercury vapor emissions from synthetic gym floors is needed.

PROPOSED MICHIGAN MERCURY FLOOR INVESTIGATION: The MDCH has proposed to create and administer to Michigan school districts a survey that will identify a representative sample of possible mercury-emitting floors and accomplish the following:

1) Educate school district administrators and staff of the potential problem and have them report the presence of synthetic floors in their school buildings.
2) Identify gyms or other schoolrooms that emit mercury vapor by measuring mercury concentrations in the air.

3) Investigate gymnasiums or other school rooms across a wide range of mercury air concentrations derived from flooring by evaluating:
   a) Air handling equipment in place, floor condition, cleaning compounds and equipment used to maintain the floors, age and manufacture of the floors, ambient temperature and humidity, and activities that take place on the floor surfaces, current and historic.
   b) Wipe samples from floor surfaces and dust collection and samples from carpeted areas adjacent to the synthetic floors.

MDCH will work closely with the MDE in this process and will contact the responding schools to gain access for sampling. In collaboration with federal, state, and county agencies that have use of Lumex mercury vapor analyzer devices (see **Chapter 6.1.1**), MDCH will screen participating schools following a sampling protocol developed jointly by the MDCH and the ATSDR. The sampling protocol will be used when a sample of 30 to 50 school floors emitting mercury vapor are identified. The data will then be sorted into high, medium, and low vapor-category school floors. Investigators will conduct additional sampling and a thorough assessment of the physical aspects of the floors, their environment, and the activities and maintenance practices that occur there. Sampling may include wipe samples to detect possible surface deterioration, dust samples from adjacent area carpets, TCLP testing of flooring material to establish disposal requirements, and biological testing of staff that spend extended amounts of time in the gym atmospheres. The expected benefits and impacts of this sampling include:

- Identifying factors that correlate with low versus high mercury concentrations from a flooring source.
- Schools with unacceptable mercury vapor air concentrations will be identified, and the exposures will be mitigated by measures to reduce vaporization or by floor removal and appropriate disposal. The results are that health hazards will be identified and mitigated.
- School floors with low-level mercury air concentrations will be identified and practices will be established to maintain them appropriately, inspect and monitor them periodically until their useful life ends and they are removed. The benefits are that limited school budgets will not be devastated by unnecessary replacement and disposal costs.
- Communities and schools will know the mercury status of their children's school environment.

ATSDR MERCURY FLOORING PROJECT: Due to the high degree of variability in the mercury vapor concentrations, it has been difficult to make generalized conclusions about why some floors are emitting an unacceptable amount of mercury vapor and some floors do not currently present a health hazard. To provide more detailed information that would enable local school authorities to make informed risk management decisions about their facilities and to provide parents and students with appropriate Public Health Communication messages, the ATSDR, in collaboration with the state public health departments in Ohio, Michigan, and Oregon, has released several Health Consultations on the Mercury Flooring Issue: These include:

- Westerville Schools (Ohio) Mercury Exposures from 3M Tartan Brand Floors; Ohio Dept. of Health, 2002[100]

[100] The Westerville Health Consultation is at: http://www.atsdr.cdc.gov/HAC/PHA/westerville/wes_p1.html.

- Mid-Michigan Mercury Floor Middleton, MI; Michigan Dept. of Community Health, May, 2004[101]
- Salem-Keizer School District 3M Flooring Health Consultation, Oregon Department of Human Services, 2006 (Public Comment Draft)[102]

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material. In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members.

The levels of estimated exposure from these assessments are generally near or below the ATSDR Action Level for assessment of residential indoor mercury exposures. However, there is a high degree of variability in the levels that have been measured and indications that the levels are higher where the surface of the material has been cut or abraded. As a result, there is a high degree of uncertainty in determining the situations where this material may be a potential problem and when it is not. This uncertainty complicates the development of defensible messages to school officials and the public. The overall objective of the ATSDR proposal is to collect the necessary information that can be used to respond to concerns about mercury exposure from flooring surfaces. Specific aims include:

1) To determine the specific factors that distinguish flooring surfaces with higher emissions from those that have minimal releases.
2) To evaluate the impact of dust/particulate release from the flooring surface and subsequent tracking to other areas.
3) To develop a communications strategy targeted to school systems, parents, other users of this type of flooring, flooring manufacturers, and the general public that will provide information to enable appropriate risk management decisions about use and disposal of mercury flooring material. This strategy would include specific recommendations for maintenance or disposal of flooring surface to limit exposure of occupants to mercury vapors.

The following are several recommended methods in accomplishing the goal of the ATSDR mercury flooring project:

Characterization of Mercury Emissions from Flooring Material: The ATSDR Health Consultations that have been issued on mercury flooring assessments are only a small subset of locations where this material has been applied and indicate a high degree of variability in mercury emissions. The initial phase of this project is targeted on the collection of data concerning the magnitude of the problem. A workgroup of ATSDR and state health department staff have developed an Inventory Form, intended to collect relevant information about

[101] Mid-Michigan Health Consultation can be found at http://www.atsdr.cdc.gov/HAC/PHA/Mid-MichiganMercuryFloor050604-MI/Mid-MichiganMercuryFloorHC050604.pdf.
[102] Information on the Salem Keizer School Health Consultation is at http://www.atsdr.cdc.gov/HAC/PHA/SalemKeizerSchoolDistrict/Salem-KeizerSchoolHC071206.pdf.

past assessments of sites where mercury emissions have been evaluated. The parameters in the inventory include method of installation (mats, rolls, or poured in place from liquid), age of flooring, use patterns, maintenance procedures, and condition of the surface.

Development of Partnerships with Flooring Manufacturers and Installers: It is expected that the manufacturers of mercury flooring products are likely to have critical information about the polymer chemistry of these materials and data on the mercury emissions from surfaces, both when polymerized in place and when installed as polymer mats. While initial inquiries with technical contacts have yielded some information, it may be useful to develop more formal agreements with the manufacturers that would provide more detailed information relevant to this investigation. Through that process it may be possible to identify data gaps in our understanding of the factors that are most critical in impacting mercury emissions, which could guide the planning of further assessment efforts. Also, partnerships with installation contractors may also provide information about the total number of facilities where these products are located, allowing for a more targeted dissemination of information.

Collection of Additional Assessment Data: Based on the data inventory from previous assessments and information gathered from manufacturers and product installers, a focused assessment on collection of additional data is needed to draw conclusions about health hazards from exposure to this material. The sampling strategy is based on the use of a Lumex (or equivalent mercury vapor analyzer) to survey instantaneous air concentrations of mercury. The National Institute for Occupational Safety and Health (NIOSH) method can be applied to obtain an average air concentration over the course of a day. It may be possible that manufacturers would be interested in funding a research project to perform field evaluations on the impact of specific maintenance procedures, types of recreational activities, and other parameters on the release of mercury.

Development of Communications Strategy: The end product of this project is the development of a communications strategy that provides scientifically defensible information about the presence or absence of health hazards associated with these types of flooring products. An additional goal is to provide specific recommendations about the appropriate maintenance and disposal of these materials that is protective of public health.

Workgroup participants include the MDCH, Oregon State Public Health, Ohio Department of Health, Minnesota Department of Health, and staff from the ATSDR.

4.2.9 DETROIT MERCURY TASK FORCE

In response to growing concerns over repeated mercury spills in schools and the resulting health risks posed to children caused by exposure to mercury, Dr. Suzanne White, Medical Director, and Dr. Susan Smolinske, Managing Director of Children's Hospital of Michigan Regional Poison Control Center, convened a series of meetings with representatives from MDCH, MDEQ, Wayne State University, Wayne County RESA, Wayne County Health Department, Detroit Public Schools, Detroit Department of Environment, and the EPA (Gross Isle Office). This group later became known as the “Detroit Mercury Task Force” and began conducting a series of mercury workshops for school personnel throughout southeast Michigan. Later, the group conducted similar

workshops at various locations throughout the state.

As the school legislation eventually took effect, this group's efforts shifted toward conducting "Emergency Mercury Spill Response" training workshops for county health departments, sheriff departments, fire departments, hazardous material specialists, mercury spill contractors, and other front-line responders. The task force realized that it is critically important in spill emergencies for people to receive timely, accurate, consistent advice and information from poison control centers, county health departments, MDCH, MDEQ, and EPA. Thus far, nearly a dozen spill workshops have been conducted throughout Michigan with more in the planning stages for 2007-2008.

Additional work performed by the Detroit Mercury Task Force includes monitoring and data tracking of mercury spill and human exposure events. This task force also formed a mercury speaker's bureau, where interested groups, media or possibly legislative committees can make a single point of contact and enlist the involvement of a panel of mercury experts. The Detroit Mercury Task Force continues to meet quarterly, sharing information and staying on top of emerging mercury-related issues.

4.2.10 SUPPLEMENTAL ENVIRONMENTAL PROJECTS (SEPS)

SEPs are commonly formed as the result of negotiated settlements between the regulated community and the MDEQ over issues relating to various environmental violations. SEPs offer companies a project alternative in lieu of paying the state formal fines or penalties. Frequently a monetary donation, equipment or project expenditure is made to support environmental projects that directly benefit the impacted area(s) where the environmental violation(s) occurred. The ESSD has been working in conjunction with MDCH and MDEQ's regulatory staff to identify and incorporate mercury P2 components into SEP settlements.

To date, three such projects have incorporated mercury P2 into SEP settlements: one in Marquette County, one in the 22-county Saginaw Bay Watershed area, and another at the U of M (Washtenaw County). As a result of these agreements, seven county environmental health departments (Saginaw, Tuscola, Bay, Genesee, Oakland, Isabella and Marquette) have received mercury vapor analyzers (Lumex RA-Lite) to enable health department staff to respond to mercury spills effectively and to help ensure public safety.[103] In addition, the SEP in the Saginaw Bay Watershed area included a $35,000 donation to the MALPH to support the "Catch the Fever" Michigan Mercury Thermometer Exchange Program.

The large SEP initiative at the U of M became known as the P2000 P2 Programs Project. This project evolved as the culmination of a settlement negotiated between U of M and MDEQ in 1995. Mercury P2 'product substitutions' were incorporated into commonly found mercury-containing devices at the U of M Medical Center as well as, the elimination of mercury use in teaching and research laboratories on campus. Specific substitutions were then summarized in case study fact sheet format to enable other learning institutions to easily replicate U of M's success.

[103] The Tuscola County Health Department no longer has the Lumex analyzer as it has been given to the Western U.P. District Health Department.

Mercury source reduction also became part of several energy conservation initiatives on campus including participation in the EPA's Green Lights and Energy Star Programs. Again, specific mercury reduction actions were documented and incorporated into a three-ring binder notebook for teaching and information sharing purposes. The SEP also included an experimental dental mercury amalgam management project where a settling tank was installed in the trap and filtration system at the U of M Dental School to capture mercury amalgam prior to its release into the municipal sewer system. The SEP also established a travel budget so the project's coordinators could share findings throughout the academic community.[104]

4.2.11 MERCURY PUBLICATIONS

The MDEQ has developed or been the lead for a number of publications concerning mercury. Following is a list of those publications along with their websites:

- *Michigan Science Teacher's Brochure* - http://www.deq.state.mi.us/documents/deq-ead-p2-mercury-hgscience.pdf
- *Case Study: Delta College: Small-Scale Chemistry* - http://www.deq.state.mi.us/documents/deq-ead-p2-mercury-deltacoll.pdf
- *Merc Concern* - http://www.deq.state.mi.us/documents/deq-ead-p2-mercury-mercbroc.pdf
- *Merc Concern: Mercury Awareness for Michigan Dairy Farmers* - http://www.deq.state.mi.us/documents/deq-ead-p2-mercury-agmercbr.pdf
- *Mercury Alert!! Bilingual Brochure* - http://www.deq.state.mi.us/documents/deq-ead-p2-mercury-hispmerc3.pdf
- *Mercury Pollution Prevention in Michigan* - http://www.michigan.gov/deq/1,1607,7-135-3585_4127_4175---,00.html
- *Mercury Pollution Prevention in Michigan, Implementation Strategy* - http://www.deq.state.mi.us/documents/deq-ead-p2-mercury-mercstrat97.pdf
- *Steps for Responding to a Large Elemental Mercury Spill* - http://www.deq.state.mi.us/documents/deq-ead-p2-mercury-lgmerc.pdf
- *Cleaning Up Small Mercury Spills* - http://www.deq.state.mi.us/documents/deq-ead-p2-mercury-mercspills.pdf
- *Mercury Elimination Guidelines for Schools* - http://www.deq.state.mi.us/documents/deq-ead-p2-mercury-mercinschools.pdf
- *Toxic Mercury Vapors Video* - http://www.michigan.gov/deq/0,1607,7-135-3307_29693_4175---,00.html, located under "Mercury Spills"
- *Broken Mercury Thermometer Video* - http://www.michigan.gov/deq/0,1607,7-135-3307_29693_4175---,00.html, located under "Mercury Spills"
- *Michigan In-Service Mercury Switch Review* - http://www.deq.state.mi.us/documents/deq-ess-p2-mercury-InServiceReview.pdf
- *Summary of Michigan's Mercury Reduction Activities; as Reported to ECOS* - http://www.deq.state.mi.us/documents/deq-ess-ECOSMercurySurvey1-10-05final.pdf

[104] For details on the P2000 Project contact: U of M, Department of Occupational Safety and Environmental Health, 1239 Kipke Drive, Ann Arbor, MI 48109-1010, or call 734-647-1143.

4.2.12 MAJOR MERCURY EVENTS AND ACTIVITIES

The MDEQ has sponsored/cosponsored or participated in numerous seminars and workshops in the state since 1998 focusing on mercury education and reduction efforts. One such annual event has been the Livonia's Waste Reduction and Energy Efficiency Workshop, where mercury displays and presentations are given. Other major mercury events and activities, listed by year (with location), include the following:

1998

- Using P2 Tools to Address Great Lakes Initiative Pollutants (Lansing and Gaylord)
- Mercury Elimination in Healthcare (Marquette)
- Mercury Reduction Efforts in Michigan (Washington, DC)
- RETAP Mercury Audit Training Workshop (Lansing)
- Wayne County Dept. of Public Works, Health Care Task Force (Detroit)
- Mercury in the Aquatic Environment: Why Small Concentrations of Mercury Pose Big Concerns (Lansing and Gaylord)
- Mercury Reduction Efforts in Michigan – Are We Making Progress? (Ontario Canada

1999

- Mercury in HealthCare Conference (Novi)
- Michigan Environmental Health Association Annual Conference, Mercury Break-Out (Frankenmuth)
- Protecting People and the Great Lakes-Focus Toward a Mercury-Free U.P. (Marquette)
- Atmospheric Deposition of Air Toxics to the Great Lakes and Michigan's Inland Lakes (Higgins Lake)
- Bi-National Strategy Mercury Workgroup – Auto Subgroup (Toronto)
- Wayne County RESA Teachers Meeting (Romulus)

2000

- Household Hazardous Waste Michigan Roundtable (Traverse City)
- Detroit Teachers Mercury in Schools Workshop (Detroit)
- Mercury Reduction Talk for the Lake Huron Initiative (Port Huron)
- Mercury P2 Formulas for Success (East Lansing)
- Coordinating Mercury Reduction Programs: A Meeting of National and Local Program Officials. Using Voluntary Programs for Action! (Baltimore, MD)
- Multi-Cultural Mercury Meetings and Presentations (Dearborn)
- Michigan School Business Officials – Mercury Reduction Education (Saginaw)
- Michigan State University (MSU), Fisheries and Wildlife Department, Mercury Class Workshops (East Lansing)
- Wayne County RESA Conference (Wayne County)

2001

- Household Hazardous Waste Michigan Roundtable (Traverse City)
- So You Spilled a Little Mercury …? (Macomb County)
- Atmospheric Deposition of Mercury in Michigan (Lansing)
- It Was Just a Little Mercury Spill (Grand Rapids)
- Update on Mercury Reduction Efforts in Michigan (Chicago, IL)
- Michigan Recycling Coalition Annual Conference (Boyne Highlands)
- Mercury P2 at Hospitals - Hurley Hospital (Flint)
- MSU, Fisheries and Wildlife Department Mercury Class Workshops (East Lansing)
- Information Integration Conference (East Lansing)

2002

- Department of Defense, Regulatory and P2 Workshop on Mercury (Battle Creek)
- Kingsford School Career Development Days (Iron Mountain)
- Wayne County Science Teachers Workshop (Detroit)
- Michigan Safety Conference (Lansing)
- Mercury Spill Workshop (Lenawee County)
- Mercury Spill Workshop (Petoskey)
- Greening in Healthcare (Ypsilanti)
- Michigan Water Environment Association Mercury Presentation (Gaylord)
- Bi-National Toxics Strategy Mercury Work Group (Chicago)
- Muskegon County PFH Conference (Muskegon)
- Michigan Industrial Hygiene Society Mini Conference (Grand Rapids)

2003

- Great Lakes Regional Mercury Workshop (East Lansing)
- Mercury Spill Workshop (Ingham County)
- RETAP Mercury Hospital Assessors Training (Midland)
- Mercury Presentation Workshop (Midland)
- Southwest Sanitarians Seminar (Hastings)

2004

- Environmental Considerations in Demolition (Livonia)
- Clean Sweep Managers Retreat (Roscommon)
- Pollution Prevention in Health Care (Livonia)
- Pollution Prevention in Health Care (Traverse City)
- The Mercury is Rising – Addressing Environmental Contaminants and Their Effects on Human Health, (3 events), (U of M, Public Health Training Center)
- Elemental Mercury Response Training (Lansing)
- Mercury Presentation on Michigan Utilities for the Indiana Mercury Utility Workgroup (Elkhart, IN)
- Atmospheric Deposition of Air Toxics to the Great Lakes in Michigan's Inland Lakes – New staff training (Novi)

2005

- Mercury Spills Workshop (Lansing)
- Mercury Exchange Program (Southfield)
- Mercury Reductions in Products and Waste (Portland, ME)
- Mercury Switch Informational Meeting (Dimondale)
- Mercury Information Show on the Cable Network (Bloomfield Hills)

2006

- Michigan Environmental Health Association (Gaylord)
- Michigan Mercury Research Workshop (Romulus)
- Mercury Spill Response Workshop (Ann Arbor)
- U.P. Environmental Health Association Annual Training Conference (Marquette)
- What Do We Know About Mercury Deposition in the Upper Midwest Workshop (Chicago, IL)

4.2.13 MICHIGAN'S MERCURY REDUCTION INITIATIVE

Under Michigan's Mercury Reduction Initiative, P2 programs and events have been responsible for capturing approximately 19,000 lbs of mercury that could have been released into Michigan's environment. **Table 4-1** lists the quantitative accomplishments of Michigan's Mercury Reduction Initiatives from 1994 to 2007. Additional key events and their mercury reduction achieved, from 1990 to 2002 are shown in **Table 4-2**.

TABLE 4-1: MICHIGAN'S MERCURY REDUCTION INITIATIVE FROM 1996 THROUGH 2007

DATE	PROGRAM OR EVENT	P2 HG REDUCTIONS		SOURCE OF INFORMATION
		LBS OF HG(0)	# OF HG DEVICES	
1994-2002	Spill and Referral Tracking Data Base EAD, AQD and MDCH EPI statistics.	279		MDEQ and MDCH 2-02
1995-2001	Green Lights Program in MI State Govt.	2		Green Lights Report; EAD (James Baker) 2000
		3		Voss Lighting Purchase Report 12/10/01
1995-2006	Consumers Energy Hg P2 Initiative (M2P2 commitment of original 2,464 lbs.)	1,488		(4,533) Michigan Mercury Electric Utility Report, 2005; CMS Energy (Pat Zombo Fax) 2-02
1996	DWSD/NWF/MDEQ Dental Mercury PMP Recovery Program	1,400	400	(400 dentists participated) DWSD Final Report (R. Hinshon) 1996
1996-2006	Detroit Edison Hg P2 Initiative (M2P2 commitment)	2,745		Detroit Edison P2 Progress Report 1998; Michigan Mercury Electric Utility Report, 2005
1998-2000	Michigan Dairy Mercury Manometer Replacement Program	158	131	Ag Manometer Final Report 2001; MDA (Gordon Robinson)
1998-2005	TRC	107.2	14,241	TRC Annual Report 2005
1999	H2E Kick-off campaign in Michigan	200	1,000	MHA P2 FY99 Annual Report
1999-2000	Groundwater Stewardship Clean Sweep Program	5,177	9,000	HHW Roundtable Report (M. Knorek) 2001
1999-2001	Pilot Thermometer Exchange Program	4	640	MDEQ and MDCH Pilot Program Summary
	MI "Catch the Fever" Mercury Programs (29)	44	16,552	MHA Final Project Report 10/01; (K. Lehmer)
2000-2001	ARM Pilot Switch Removal Project	6	3,000 switches	ARM Report on Pilot Project 2001
2000-2005	Lansing Board of Water and Light	450		Michigan Mercury Electric Utility Report, 2005
4/2001-2002	Groundwater Stewardship Clean Sweep Program	1,300	11,000	MDA (J. Knorek) \10-01
2002	Thermometer Exchange Program	1.5	900	Lake Superior Initiative Hospital Estimates
2002-2006	Michigan "Catch the Fever" Mercury Thermometer Exchange Program	1,000	23,010	Program Partner MALPH sponsored 81 exchanges. Contact: Julie Zdybel, 485-0660
2003-2006	Michigan Groundwater Stewardship Clean Sweep Program	2,740.9	87,538 devices	MDEQ Spreadsheet Tracking Bi-annual Reports for 2003-2006
2004-2006	M2S2 Program	94.6	42,931 switches	SRG M2S2 Program Summary Report
2004-2006	EPA Funded School Collections	971	1,823	Suero, 2007 (EPA)
2006	M2S2 second 'milk run' to EQ -Final	9	2,714 switches	(2) 55 gallon drums 236 lbs. net weight total
2006	TRC	28.69	3,528	TRC website http://www.nema.org/gov/ehs/trc/
2007	Michigan Groundwater Stewardship Clean Sweep Program	776.17	4,640	MDEQ Spreadsheet Tracking Bi-annual Reports for 2007
TOTAL P2 REDUCTIONS SINCE 1994		**18,985.06 lbs.**	**223,048 Devices**	

TABLE 4-2: MICHIGAN'S KEY EVENTS ACHIEVING ADDITIONAL MERCURY REDUCTIONS FROM 1990 TO 2002

DATE	EVENT	SOURCE OF INFORMATION
1991	Mercury banned from Latex Paint and is no longer used in fungicides	MDCH/MDA
1996	Mercury-Containing and Rechargeable Battery Management Act eliminates all but trace mercury from batteries	(Public Law 104-142) took effect on May 13, 1996.
2001-2004	P.A. 376 Mercury in Schools -- Schools had until 12/31/2004 to remove liquid mercury and mercury instruments	6,000 K-12 schools (estimated) in Michigan
1995-2002	Big 3 Commitment to Eliminate Mercury convenience lighting switches	Mercury switch use phased-out in vehicles.
1998	American Hospital Association / EPA MOU Goal: Virtual Elimination (80 of 176 pledged Hg-free)	H2E Voluntary Agreement 1998
2002	P.A. 578 of 2002 Banned the Sale of Mercury Thermometers in Michigan	Rep. Minore (et. al.) sponsor

4.3 GREAT LAKES MERCURY IN PRODUCTS PHASE-DOWN STRATEGY

The action plan for the Great Lakes Regional Collaboration's (GLRC's) Toxic Pollutant Strategy (discussed in **Chapter 5.4.4**) states that the "Great Lakes States and Tribes will develop a basin-wide mercury products stewardship strategy which will establish a basin-wide mercury phase-down program, including a mercury waste management component." High level support for this regional strategy was offered in a December 12, 2005, letter to President Bush from the Council of Great Lakes Governors and the Great Lakes and St. Lawrence Cities Initiative. This letter also established a leadership role for the Great Lakes Regional Pollution Prevention Roundtable in the above process. The MDEQ Director has appointed Steve Kratzer, ESSD, as the point person to represent Michigan on this initiative. The draft Great Lakes *Mercury in Products Phase-Down Strategy* was made available for public comment through October 27, 2007. Comments received during the public comment period are now being evaluated and addressed.[105]

The regional strategy established a goal template for other regional strategies to follow. A regional strategy that addresses air emissions of mercury, possibly modeled after the NEG/ECP plan (see **Chapter 5.4.2**), should also be developed and implemented in the region to further reductions.

4.4 FUTURE MERCURY P2 OPPORTUNITIES

There are several other sources of mercury that have potential for mercury elimination through employing P2 techniques. These include but are not necessarily limited to:

4.4.1 HEALTH CARE OUTREACH EXPANSION

Although Michigan has aggressively pursued mercury elimination in hospitals, additional opportunities still exist to promote mercury P2 practices in individual doctor's offices, rural clinics, satellite facilities, visiting nurses organizations and nursing homes. MDEQ should join forces with Michigan H2E to ensure these health care sectors are getting the message and that they know about the Clean Sweep Program where Hg(0) and mercury-containing devices may be disposed or recycled at no charge.

In addition, veterinary uses of mercury are similar in nature to most health care facilities. Many of the same instruments and devices that contain mercury, including lab stains

[105] Responses to comments received are available at http://www.glrc.us/documents/MercuryStrategyResponsetoStakeholderComments.pdf.

and reagents are also found at these clinics. Aside from some preliminary discussion with the MSU School of Veterinary Medicine, this sector has yet to be engaged by the Michigan Mercury Reduction Initiative. Any new initiative of this magnitude would, however require substantial additional resources for the MDEQ and strong commitments by the veterinary industry, stakeholders, and local agencies.

4.4.2 DENTAL

Thanks to the implementation of successful mercury P2 measures in areas such as hospitals, laboratories, and paper mills, dental practices are emerging as the largest remaining source of mercury entering WWTPs. Several recent reports estimate that dental practices are responsible for as much as 40-50% of all the mercury entering WWTPs (QSC, 2006). Research has shown that dental practices can discharge both elemental and organic forms of mercury (Stone et al., 2003), and that mercury from dental amalgam can become bio-available from a number of pathways including airborne, aquatic and terrestrial sources.

Nationally, dental amalgam capsule manufacturers reported to the IMERC that more than 30 tons of dental mercury amalgam was sold in the U.S. in 2001. Given such high mercury use and visibility, it is anticipated that the dental community will be facing increased environmental challenges and further scrutiny toward eliminating mercury discharges from its wastewater stream. Best dental mercury amalgam management practices, which include amalgam separators and waste amalgam manifest tracking, are being promoted by states, tribes and federal agencies as an area in need of increased action, as described in recent drafts of the Great Lakes *Mercury in Products Phase-Down Strategy* (August 2007)[106] and in the QSC *Mercury-Containing Product White Paper* (November 2006).[107] Currently, QSC members are drafting a detailed white paper which examines the key aspects of several regional and state dental best management practices programs.

As of October 2007, the following eleven (11) states require the installation, proper operation and maintenance of dental mercury amalgam separators. This is in addition to dozens of communities which now require amalgam separators under their PMPs.

- Connecticut
- Louisiana
- Massachusetts
- Maine
- New Hampshire
- New Jersey
- New York
- Rhode Island
- Vermont
- Washington (state)
- Oregon

In Michigan, the MDEQ's WB and local municipal PMPs are expected to continue promoting dental facilities to use effective mercury reduction approaches in order to eliminate mercury amalgam from entering wastewater and potentially being released to the environment. As mentioned in **Chapter 4.2.6**, it does little to ease mercury pollution

[106] Information on the Great Lakes Mercury in Products Phase-Down Strategy is available at http://www.glrc.us/initiatives/toxics/drafthgphasedownstrategy.html.

[107] The Mercury-Containing Product White Paper, published in November 2006, is at http://www.ecos.org/files/2727_file_Mercury_Added_Product_White_Paper_formatted_final_with_MS_changes.pdf.

in the waste stream if recycling or proper disposal methods are not employed. The issue of mercury elimination is of particular concern to Michigan communities in the Great Lakes region where very strict mercury discharge limits exist under the Great Lakes Initiative. Fortunately, ISO, a national standard setting and testing organization, has established ISO Method 11143 which sets forth standard testing protocol to accurately measure the efficiency of mercury removal from amalgam separator equipment. Recent studies on amalgam separators have shown mercury reductions of 97-99% are now readily achievable for using any of nearly two dozen amalgam separator units provided they are properly operated and maintained.

New approaches in plumbing adaptation have also been developed specifically for dental practices in order to capture and isolate dental wastewater that is known to contain dental mercury amalgam. One Michigan company now provides services that redirects wet and/or dry suction lines receiving mercury amalgam, to vats or holding tanks typically installed in the clinic's basement. A similar approach is being used by the U of M's Dental School. These holding tanks remove and store mercury-containing fluids separate from the rest of the wastewater lines. The tanks are periodically disinfected and as they become full or in need of service, a licensed hazardous waste transporter pumps out the storage tank and transports the material off-site for proper treatment and disposal. The collected material is treated, solidified, and disposed of in a licensed landfill.

Research into these and other mercury management technologies, along with finding and promoting mercury-free alternative restorative materials, is projected to grow in importance. Ultimately, the long-term result could be the elimination of mercury use altogether as a dental restorative material. Should this eventually occur, the practice would be consistent with the overarching goal of this strategy, which is to eliminate both the use and release of mercury to Michigan's environment.

4.4.3 THERMOSTAT RECYCLING

The TRC, subsidiary of GE-Honeywell, operates a thermostat take-back program that up until recently primarily targeted wholesalers and contractors. The program began operating in eight Midwest states (including Michigan) and Florida in 1998. From 1998 to 2006, more than 14,000 thermostats have been recovered from Michigan (see **Table 4-3**). This equates to about 135 lbs of mercury. As state officials, environmental groups, and non-profit interest groups continue to push for increased thermostat recycling, the TRC recovery initiative is expected to continue to grow. MDEQ's assistance in education and outreach activities could help promote an expansion of recovery efforts in Michigan. Currently, the TRC program is being expanded nationally to serve smaller contractors and HHW programs. This should be expanded to take place in Michigan as well.

TABLE 4-3: MERCURY THERMOSTAT RECYCLING PROGRAM IN MICHIGAN

YEAR	NUMBER OF THERMOSTATS RECOVERED
1998	498
1999	831
2000	1,060
2001	1,701
2002	2,320
2003	2,289
2004	2,969
2005	2,573
2006	3,528
TOTAL	**14,769**

Another significant concern is the thermostat industry's continued use of mercury in the manufacture of thermostats when energy efficient, cost comparable, programmable, convenient mercury-free devices exist. Most of these alternatives are electronic devices; however, some simply incorporate a different switch absent any mercury. In addition to the advantages mentioned above, mercury-free thermostats are safer in the home and pose far less risk for human exposure or release of mercury to the environment if improperly discarded. Some states have partnered with home improvement stores and hardware stores such as True Value to disseminate education/outreach materials and provide mercury thermostat drop-off opportunities for customers.

Presently, all of Michigan's Clean Sweep Programs accept mercury-containing thermostats for recycling/disposal as do many local HHW programs (see **Chapter 4.2.7**). In fiscal year 2006 and 2007, the Clean Sweep Program captured a total of 1,104 thermostats (561 and 543, respectively).

4.4.4 GREEN CHEMISTRY INITIATIVE

In October 2006, the Governor issued the Green Chemistry Executive Directive, No. 2006-6, to establish a Green Chemistry Support Program and Green Chemistry Support Roundtable within the state of Michigan. Its purpose is to promote green chemistry for sustainable economic development and protection of public health (see **Appendix P**).

The MDEQ has been given primary responsibility to implement the Green Chemistry Executive Directive, including convening a Green Chemistry Support Roundtable and establishing a Green Chemistry Support Program. The Green Chemistry Support Program has responsibility for promoting and coordinating state green chemistry activities such as research, development, and demonstration, education, and technology transfer activities in Michigan. The objective is to foster use and development of new chemicals and chemical products that reduce or eliminate the use or generation of hazardous substances (like mercury) while producing high quality products. The MDEQ is meeting with stakeholders to seek out ways to promote and foster green chemistry research, development, demonstration, education, and technology transfer activities in Michigan. Of particular concern will be avoiding the manufacture of formulated mercury-added products. It is important that those administering the Green Chemistry Initiative are fully aware of the need to eliminate mercury use.

5. POLICIES LIMITING THE RELEASE OF MERCURY TO MICHIGAN'S ENVIRONMENT

5.1 AIR

GREAT LAKES WATER QUALITY AGREEMENT (GLWQA)

Significant efforts have been implemented to identify and limit mercury emissions from sources in Michigan for over a decade. The GLWQA signed by both the U.S. and Canada in 1978, and amended in 1987, identified mercury as one of the pollutants that should be "virtually eliminated" due to its toxic and persistent nature. Annex 15 of this agreement also identified atmospheric deposition of toxic substances as important enough to require pollution control measures and/or alternative products to reduce or eliminate the sources of emissions of the persistent substances that significantly contribute to pollution of the Great Lakes System (GLWQA, 1987). After nearly 20 years, the GLWQA is currently undergoing a review process. The draft Bi-National report reviewing the GLWQA is presently out for public comment.[108]

TOXIC SUBSTANCES CONTROL AGREEMENT

The Toxic Substances Control Agreement was a report of the Great Lakes Governors that agreed to, "consider the effects of airborne pollutants on human health and aquatic life, and to better integrate their respective air and water programs to address atmospheric deposition affecting the lakes." They agreed that a regional computerized database of toxic air pollutants be developed and they also agreed that the BACT should be applied wherever possible on both new and existing sources to control air emissions of persistent toxic substances (Toxic Substances Control Agreement, 1986). These agreements led to the development of a Regional Air Pollutant Inventory Development System and the signing of the Great Lakes States Air Permitting Agreement (**Appendix Q**).[109]

GREAT WATERS PROVISION

In addition to the regulations that have been adopted under the CAA (described in **Chapter 3**), there was also a provision in the 1990 CAA known as the "Great Waters" (Section 112m) provision which required atmospheric monitoring of hazardous air pollutants to the Great Lakes, the Chesapeake Bay, Lake Champlain, and coastal waters. An air monitoring network, known as Integrated Atmospheric Deposition Network was also established; however, there was not significant funding for mercury monitoring.

AQD drafted a document, "*The Development of an Air Toxics Monitoring Strategy for Michigan*" on June 27, 2002, that did include mercury monitoring.[110] As part of the Great Waters provision, money has been allocated from EPA to the Great Lakes states since 1991 to fund research projects focused on identifying and better understanding environmental fate and health impacts from atmospheric deposition of mercury to the Great Lakes Basin. AQD continues to be involved in reviewing proposals for projects focused on mercury and other PBTs in the basin. The grants are administered by the Great Lakes Commission.[111]

MULTI-PATHWAY RISK ASSESSMENTS

Michigan's Governor announced in 1991 that a statewide mercury reduction strategy would be developed. Following this announcement, a state task force, which included MDEQ (previously known as MDNR), MDCH, and MDA staff, was convened. This task force was asked to compile information on the current state of knowledge on mercury in the environment to assist in development of the statewide mercury reduction strategy. Their

[108] The draft Bi-National report is available at http://binational.net/glwqa_2007_e.html.
[109] Information on the Regional Air Pollutant Inventory Development System is at http://glc.org/air/.
[110] The Strategy is available at http://www.deq.state.mi.us/documents/deq-aqd-toxics-peerRVstrategy.pdf.
[111] For more information on the commission grants, visit http://www.glc.org/glad.

report was completed in 1992 (MDNR, 1992). The Governor's MESB, appointed in August of 1992, was directed to address the mercury issue by proposing and evaluating options for controlling or eliminating harmful emissions of mercury into the environment (MESB, 1993).

The policy that followed in the early 1990s stated that any applicant submitting a permit to install for a municipal waste combustor or a hazardous waste incinerator would be required to conduct a multi-pathway risk assessment to address concerns from paths of indirect exposure to such pollutants as mercury, dioxin, and lead. Since this policy's inception, the AQD drafted and implemented air toxics rules in 1994 to address the release of toxic air pollutants (discussed in **Chapter 3.1.2**)

21ST CENTURY ENERGY PLAN

On April 6, 2006, Governor Granholm issued Executive Directive 2006-2[112] directing the DLEG's MPSC to develop a 21st Century Energy Plan that will outline ways to provide affordable, reliable, safe, and clean electricity for citizens and businesses. As part of the directive, the MPSC was asked to establish a renewable energy portfolio for Michigan that will encourage the production and use of alternative energy sources by requiring that a certain percentage of the state's energy supply come from renewable sources. The following were several specific recommendations listed in the directive:

- meeting the state's short and long-term electric needs for residential, industrial, commercial and governmental customers in a way that ensures a reliable, safe, clean and affordable supply;
- reducing reliance on fossil fuels through energy efficiency, alternative energy, and renewable energy technologies consistent with the goal of assuring reliable, safe, clean and affordable energy;
- protecting natural resources and the environment from pollution, physical or visual impairment, or destruction and future risks associated with fossil fuels;
- developing a renewable portfolio standard which will establish targets for the share of the state's energy consumption that should come from renewable energy sources;
- identifying new technology options to generate, transmit, or distribute energy more cleanly or more efficiently;
- fostering continued growth of alternative and renewable energy technologies within the state by ensuring development of the intellectual capital, financing, infrastructure, and other resources necessary for the growth of the industry; and,
- identifying any legislative or regulatory changes necessary to its implementation, together with any financial, funding, or incentive mechanisms needed to best position the state to meet the energy challenges of the future.

The MPSC held its first meeting on April 24, 2006, working in cooperation with representatives from the public and private sectors, including the MDEQ and other appropriate state departments. The final report was submitted to the Governor on January 31, 2007. Included in the report were two appendices: Appendix I contains staff policy recommendations; and Appendix II contains the resource assessments for each of the following workgroups: Capacity Need Forum Update Workgroup; Renewables Workgroup, Energy Efficiency Workgroup, and the Alternate Technology Workgroup.

The MSWG recommends that work should be continued on ensuring implementation of the Governor's 21st Century Energy Plan to increase the use of renewable resources and improve conservation energy efficiency programs, thereby decreasing Michigan's reliance on fossil fuels.

[112] Directive 2006-2 is available at http://www.dleg.state.mi.us/mpsc/electric/capacity/energyplan/index.htm.

5.2 WATER

POLLUTANT MINIMIZATION PROGRAMS (PMPS)

PMPs are designed to identify and remove sources of toxic substances to meet a WQBEL. Described in the NREPA's Part 8 Rule 1213(1)(d), these special conditions are part of specific NPDES permits or an equivalent document and require the permittee to develop and submit a PMP for each toxic substance with a WQBEL below the quantification limit within a specified deadline to the appropriate District Supervisor. This PMP must include a description of the control strategy designed toward the goal of maintaining effluent concentrations of the toxic substances at or below the WQBEL. Once this plan is approved, the permittee is required to implement the PMP and provide yearly updates that document progress toward achieving the goal as described in Rule 1213(1)(d).

Because each permitted facility and discharge is unique, the specifics of individual PMPs may be highly variable, containing site-specific strategies necessary to reach the intended goal. Rule 1213 requires that all PMPs be composed of essentially the same fundamental components in that they require:

- An annual review and semiannual monitoring of potential sources of the toxic substance.
- Quarterly monitoring for the toxic substance in the influent to the wastewater treatment system.
- A commitment by the permittee that reasonable cost-effective control measures will be implemented when sources of the toxic substance are discovered.
- An annual status report sent to the appropriate District Supervisor that includes:
  - all minimization program monitoring results for the previous year;
  - a list of potential sources of the toxic substance; and
  - a summary of all actions taken to reduce or eliminate the identified sources of the toxic substances.

As a part of this program, the permit may contain requirements for facility sludge monitoring, fish tissue sampling, or other bio-uptake sampling to assess the progress of the PMP. In addition, PMPs are recommended when data indicate the presence of a toxic substance with a WQBEL below the quantification level (covered by Rule 1213) and/or a variance has been granted per Rule 1103(6)(b) or (9). As an example, PCBs are a class of pollutants that have a quantification level well above the WQBEL. A PMP will be required under the authority of Rule 1213 when a facility has been identified as potentially discharging PCBs above the WQBEL.

PMPs were originally created for mercury in the same fashion as the PCB example above when the WQBEL for this metal was less than the quantification limit. However, the promulgation of EPA Analytical Method 1631 now allows for the quantification of mercury at a concentration that is less than the WQBEL. Because of this new analytical method, the continuation of existing PMPs and the creation of new PMPs for mercury will occur under the authority of Rule 1103.

5.3 RECYCLING VERSUS RETIREMENT

As Michigan residents and businesses work toward elimination of mercury in the products they use and the wastes they generate, ever increasing amounts of mercury will be collected. While the hazards of Hg(0) have been stated and therefore justify its reduction and elimination in products, the question remains as to what to do with the Hg(0) when it is recovered. Should Hg(0) continue to be recycled or should it simply be retired?

As mentioned previously, recycling is encouraged by Michigan's Universal Waste Rule. Recycling is intended to promote the reuse of a valuable material. However, is it appropriate in the case of a persistent toxic pollutant? The argument has been made that if there is no Hg(0) available, it would encourage the mining of virgin mercury thereby releasing more Hg(0) into the biosphere. Therefore, recycling of some Hg(0) perhaps makes sense for those essential items that still require Hg(0), such as fluorescent lights (examples of various types are shown at the right). However, currently there is an excess of Hg(0) available in the U.S. beyond what is needed for those essential items, and the surplus is commonly exported to developing countries where they continue to use Hg(0) in products and for mining activities.

With the U.S. and other developed countries continuing to phase out the use of Hg(0), the export flow of Hg(0) is now greater than any imports of Hg(0) into the U.S. Recently, EPA estimated that about half of the mercury used globally came from mines in Spain, Algeria, and Kyrgyzstan and the other half from recycled mercury from mercury-containing products, mercury recovered as a by-product of mining, and from the closure of mercury-cell chlor-alkali plants (Maxson, 2004; cited in EPA, 2006b). In addition, the price of gold has increased, driving up the demand for mercury used in such activities as artisanal gold mining (Swain et al., 2007). This continued use and emissions of mercury can impact our country and state by long-range transport and deposition from ongoing application in developing countries.

Since Hg(0) is still a commodity and is bought and sold on the global market, an understanding of micro-economics is needed to thoroughly understand the theory of price and the science of the markets to fully explain the nuances involved. Because the MSWG did not have an economist on staff to investigate this matter, they reviewed what the following states, countries or agencies have done to address the mercury recycling/retirement issue:

- The issue of surplus Hg(0) first came to light in the mid-1990s when it was discovered that the U.S. Defense Logistics Agency – Defense National Stockpile Center was storing 9 million lbs of Hg(0) in various locations throughout the U.S. (there was not a location in Michigan) and were proposing to sell this Hg(0). Several states including Michigan, sent letters from their governors to the Secretary of Defense and the EPA Administrator opposing the sale of this mercury. This prompted the development of an Environmental Impact Study and a rather intensive public comment period. The result was that the sale of the mercury stockpile has been suspended and the Hg(0) has been consolidated by the Defense National Stockpile Center in the state of Nevada where it is being stored.
- Many states and local governments have been encouraging public and private collection programs. However, as states do not have the resources or desire to store surplus mercury, there has been a resolution adopted by the QSC expressing the need for national leadership and vision for Hg(0) (EPA, 2006b).[113]
- EPA published a report in April 2005 on the technical and economic feasibility of selected land disposal technologies in a monofill (EPA, 2005b). The issue of whether the federal government, states, or the private sector should take responsibility for storing commodity-grade mercury supplies is an important and complex policy decision. In 2006, EPA stated that they will work with other federal agencies to initiate a process with technical experts and interested parties to discuss options for addressing the expected mercury surplus (EPA, 2006b).

[113] The ECOS resolution is available at http://www.ecos.org/files/1919_file_Copy_of_Resolution_06_1.pdf.

- In February 2007, the EPA announced that it is convening a multi-stakeholder group (Blue Ribbon Panel) to address management of private domestic surplus mercury arising from closure of chlor-alkali plants, collection of mercury-added products, and recovery as a by-product of gold mining. On March 21, 2006, ECOS Resolution Number 06-1, Mercury Retirement and Stockpiling, was approved.[114]
- Sweden has made a decision to phase-out the use of Hg(0) and not export it to developing countries. Their plan is to retire the Hg(0) by placing it safely and permanently in deep geological storage. This Hg(0) does not have to undergo refinement as it would if it were sent to recycling. (SOU, 2001)
- The European Union drafted a regulation to ban Hg(0) exports in an effort to eliminate the surplus of Hg(0) from the global market (European Commission, 2005).
- QSC drafts *Principles for Management of Commodity Grade Elemental Mercury* (May 2007).

As industry finds alternatives to the uses of mercury, and as mercury-cell chlor-alkali plants phase out the use of mercury in their processes, EPA expects that there will be an excess supply of commodity-grade Hg(0) on the global market in the near future. As a result, when the global demand for mercury decreases, mercury mines will close (as a mine in Almaden Spain has recently done), and an excess supply of mercury will become available. Because mercury should only be used in applications where no feasible alternative exists, long-term storage rather than recycling should be encouraged. Therefore, it is important that Michigan adopt a global perspective when looking at long-term management of mercury, ensuring that mercury collected at the end-life of the mercury-containing products ends up in appropriate uses or long-term environmentally safe storage facilities rather than recycled.

5.4 REGIONAL/NATIONAL/INTERNATIONAL PROGRAMS

In various parts of the world, numerous efforts and activities to phase out mercury use including implementation of strict regulations, is being carried by such groups as the UNEP[115], Swedish EPA[116], and Zero Mercury Global Campaign[117] (additional global mercury initiatives is available in **Appendix R**).

Historically, reduction challenges for an initial list of persistent targeted toxic substances, including mercury, was established through the Bi-National Toxics Strategy (BNS). The BNS is the Canada-U.S. strategy for the Virtual Elimination of persistent toxic substances in the Great Lakes Basin (see **Chapter 5.4.2**).

The MDEQ, representing air, waste, water, and P2, has had input and involvement at the international, national, and regional level to address mercury sources, reductions, and other programs as well. For example, at the international level, the MDEQ has historically been involved with such organizations as the Sound Management of Chemicals Initiative's North American Regional Action Plan (NARAP) and the CEC (discussed in **Chapter 5.4.5**) by participating in meetings on their mercury NARAP, and sharing information on mercury sources and P2 opportunities. On October 30, 1998, MDEQ drafted a letter to the CEC that included recommendations for:

- regulation of coal-fired electric utilities limiting mercury emissions;
- acquiring better mercury emissions data from steel mills, refineries and taconite processing facilities;
- data collection on fugitive mercury emissions;

[114] ECOS Resolution 06-1 is available at http://www.ecos.org/files/1919_file_Copy_of_Resolution_06_1.pdf.
[115] Information on the UNEP is available at http://www.unep.org.
[116] Swedish EPA information can be found on http://www.internat.naturvardsverket.se/.
[117] The Zero Mercury Global Campaign is available at http://www.zeromercury.org/index.htm.

- encouraging a national/international education/awareness day on mercury;
- a national labeling law; and
- proper management of stockpiled Hg(0).

Nationally, MDEQ staff participated on the planning committee for an ECOS mercury conference held in St. Louis in October 2000. In 2001, the QSC was formed under the auspices of ECOS and staff from the AQD and ESSD, representing Michigan, participate regularly in mercury-related initiatives. These initiatives include the development of resolutions, policies, and program recommendations developed by both the ECOS and the QSC (see **Chapter 5.4.1**).[118] In addition, as a participant of the QSC, the MDEQ has provided information and/or has been involved in the development of several QSC publications including the: "*Elements for Developing a National Mercury Reduction Strategy to Achieve Water Quality Standards*" and "*Quicksilver Caucus Best Management Manual*" covering mercury storage. In 2005-2007, MDEQ was involved in the development of the following four QSC publications:

- *Removing Mercury Switches from Vehicles; A Pollution Prevention Opportunity for States* (August 2005) and
- *2005 Compendium of States' Mercury Activities* (October 2005) (also discussed in **Chapter 5.4.1**),
- *Mercury Product Labeling; Information for States* (March 2006).
- *Principles for Management of Commodity Grade Elemental Mercury* (May 2007)

Recently, ESSD staff assumed a leadership role in developing the QSC *Mercury-Containing Product White Paper* which will help set future priorities and coordinate EPA's mercury work.[119] MDEQ delegates were also recently asked by EPA to serve on a multi-stakeholder group (Blue Ribbon Panel) to address management of private domestic surplus mercury arising from closure of chlor-alkali plants, collection of mercury-added products, and recovery as a by-product of gold mining.

At a regional level, MDEQ staff have been involved with the Great Lakes Regional Collaboration in the creation of the *Great Lakes Mercury in Products Phase-Down Strategy* and the recent Mercury Emission Reduction Initiative effort (see **Chapter 5.4.4**). ESSD and AQD staff also participate in a regional mercury workgroup, facilitated by the EPA Region 5, which shares the latest information with the EPA and other Great Lakes' states on mercury issues, including such topics as new regulations, research, reduction, policies, P2 measures, health-related topics, uses, alternatives, spills, education, etc.

The following chapters discuss the efforts that have been made by Michigan and other states, provinces, and countries, to assist in the development, implementation, and strengthening of mercury-reduction efforts with an emphasis on elimination.

5.4.1 QUICKSILVER CAUCUS (QSC)

The QSC was formed in May 2001 by a coalition of state environmental association leaders to collaboratively develop holistic approaches for reducing mercury in the environment. Caucus members who share mercury-related technical and policy information include the ECOS, the Association of State and Territorial Solid Waste

[118] Details on these developments are available on the ECOS website at http://www.ecos.org/section/committees/cross_media/quick_silver?PHPSESSID=60edd87da5e4b42a0c866004fbb29480.

[119] The Mercury-Containing Product White Paper, published in November 2006, can be found at http://www.ecos.org/files/2727_file_Mercury_Added_Product_White_Paper_formatted_final_with_MS_changes.pdf.

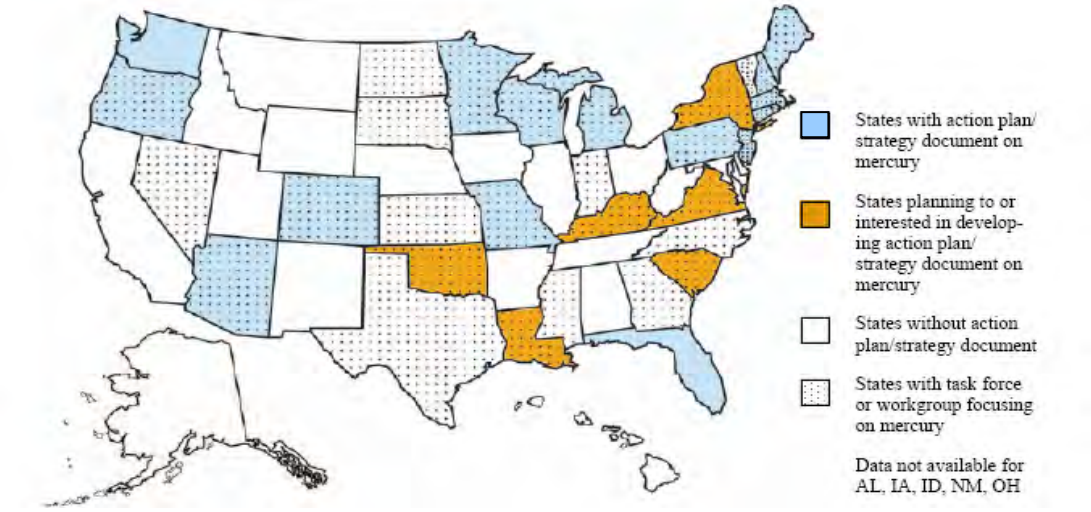
Management Officials, the National Association of Clean Air Agencies, the Association of State and Interstate Water Pollution Control Administrators, the Association of State Drinking Water Administrators and the National Pollution Prevention Roundtable. The QSCs' long-term goal is that state, federal, and international actions result in net mercury reductions to the environment. The QSC is working collaboratively and in and in partnership in three priority areas:

- Stewardship approaches for reducing mercury in the environment and managing safe, long-term storage of Hg(0) nationally and internationally.
- Multi-media approaches for a mercury-based TMDL taking into account the contributions of the air and waste program as well as using their statutes to craft solutions.
- Approaches to decrease the global supply and demand for mercury.

The QSC Committee is also developing a survey to identify state regulatory agency staff with special language skills and mercury policy expertise to assist less developed countries on mercury product stewardship initiatives.

In early 2005, the QSC in conjunction with the NWF asked states to complete a comprehensive survey about their efforts to address mercury pollution. As shown in **Figure 5-1**, forty-five states, including Michigan, responded to the survey. The information, broken down into a national mercury action plan overview and individual state summaries, was compiled into the *2005 Compendium of States' Mercury Activities Report*.[120]

FIGURE 5-1: STATES WITH MERCURY ACTION PLANS AND TASK FORCES



The report found of the 45 states that responded, 30 states have task forces or workgroups that focus on a specific mercury issue such as: the health effects of mercury; fish consumption advisories; mercury air emissions; mercury-containing products; mercury's impact on public health; government procurement; health care uses; public education; mining; and TMDLs. Sixteen of the 30 states have developed an overall mercury action plan or strategy document and 13 of those state plans/strategies include related statutes and/or regulations. The most common major elements of these mercury action plans include:

[120] The ECOS QSC's October 2005 complete report is available at http://www.ecos.org/files/1952_file_Full_Compendium_Final_03312006.pdf.

- mercury recycling;
- public outreach and education to reduce exposure;
- small business and household mercury waste management;
- medical and dental mercury waste management; and
- reduction of mercury use in consumer products.

The following are additional elements for six of the 13 individual state mercury action plans discussed in the QSC Compendium Report (Note: Not an exhaustive list). [121]

CONNECTICUT

Connecticut's top intrastate mercury sources include municipal waste combustors, sewage sludge incinerators, and coal-fired EGUs. Current state regulations address mercury releases from coal-fired EGUs, municipal waste combustors, medical waste incinerators, and dental facilities. In addition, their mercury action plan includes:

- required labeling on all mercury-containing products;
- phase-out of mercury-containing thermostats, switches, and products containing > 1 g or 250 ppm of mercury;
- banning the sale of mercury-containing thermometers, dairy manometers, and novelties;
- restricting the sale and use of Hg(0);
- mandatory manufacturer collection of mercury waste and mercury-containing products;
- prohibiting the sale of new vehicles with mercury switches.

Connecticut has also provided comprehensive mercury monitoring that continues to be updated, funding to Connecticut-based education institutions for research, and continual testing of fish from numerous waterbodies for their statewide fish consumption advisory. In addition, mercury monitoring is conducted for emissions, wastewater discharges, mercury collection, waterbody sediments, deposition, and mercury cycling. [122]

MASSACHUSETTS

Massachusetts's top intrastate mercury sources are municipal solid waste incinerators, residential/commercial boilers, and wastewater treatment (includes sewage sludge incinerators). The state's overall mercury action plan has a goal of virtually eliminating all anthropogenic sources of mercury with a 75% reduction by 2010. In addition, Massachusetts also participates in the NEG/ECP mercury action plan. Current state laws and policies include:

- strict state regulations on mercury releases from coal-fired EGUs (85% by 2008 and 95% by 2010), municipal waste incinerators, dental offices, and wastewater treatment;
- municipal waste incinerator rules require facilities to implement mercury source separation plans in their watersheds;
- 2006 regulations are being adopted requiring dentists to install amalgam separators; and
- a ban on the sale of mercury thermometers (a statewide collection program recycled more than 95,000 thermometers).

Massachusetts conducts on-going fish tissue monitoring and has a statewide fish consumption advisory. Mercury monitoring includes emissions, wastewater discharges,

[121] Michigan's compiled mercury activities are available at http://www.deq.state.mi.us/documents/deq-ess-ECOSMercurySurvey1-10-05final.pdf.
[122] Connecticut info is at http://www.ct.gov/dep/cwp/view.asp?a=2708&q=324014&depNav_GID=1638.

mercury collection, deposition, waterbody sediments, and wildlife. In addition, Massachusetts collaborates with other Northeastern states, universities, and EPA New England to implement a variety of monitoring programs, co-sponsors pilot testing of continuous emission monitoring systems, and supports university research on amalgam separator technology. Additionally, in lieu of TMDLs, Massachusetts joined Maine in submitting an alternative proposal to EPA.[123]

MINNESOTA

Minnesota's top intrastate mercury sources are coal-fired EGUs, mining, and EAFs. Additional major elements of their mercury action plan include preventing mercury pollution from existing iron/taconite mine operations; mercury emission limits; limiting mercury discharges into water; and setting goals for mercury reduction under their TMDL program (93% reduction from their 1990 baseline or a 76% reduction from 2005 due to current significant reductions) (see **Chapter 3.2.1** for TMDL information). The state's current laws and policies include:

- State regulations on mercury releases from wastewater treatment, municipal solid waste incinerators, medical waste incinerators, and broken mercury-containing products and spills.
- Specified mercury-containing products must be labeled, and disclosure is required to lamp purchasers.
- Phase-out sale of mercury-containing dairy manometers, toys, games, thermometers, inks, pigments, dyes, paints, and fungicides.
- A Memorandum of Agreement regarding the installation and maintenance of mercury dental amalgam separators statewide.
- Ban on all product disposal in solid waste.
- Mandatory recycling of collected mercury (state law requires counties to have a HHW collection program available).
- Mandatory removal of mercury switches from end-of-life passenger vehicles.
- Manufacturers of mercury displacement relays are required to provide a system for collection and recycling of end-of-life relays.
- Manufacturers of mercury thermostats are required to provide education and incentives for recovery and recycling of end-of-life thermostats.

Minnesota participates in the national MDN, has on-going fish tissue sampling and testing, monitors lake sediment and loons, has developed a draft statewide mercury TMDL plan, and has a general fish consumption advisory for all its waterbodies.[124]

OREGON

The top intrastate mercury sources in Oregon are mines and coal-fired EGUs. Elements of their mercury action plan include prevention of mercury pollution from existing mine operations, technical assistance for industries, and the following laws and policies:

- State regulations on mercury releases from industrial boilers, municipal waste incinerators, and hazardous waste.
- Labeling is required for mercury-containing thermometers.
- Phase-out of mercury-containing thermostats.
- Mercury limits in batteries.
- A sales ban on mercury-containing fever thermometers, trinkets and amulets.

[123] The Massachusetts mercury website is at http://www.mass.gov/dep/toxics/stypes/hgres.htm.
[124] Minnesota provides mercury information at http://www.pca.state.mn.us/air/mercury.html.

- Mercury collection programs for Hg(0), mercury waste, and mercury-containing products.
- Voluntary removal of mercury switches from on-road passenger vehicles; mandatory removal from end-of-life passenger vehicles; and mandatory prohibition on sale of new passenger vehicles with mercury switches in 2006.

Oregon participates in the national MDN; monitors wastewater discharge, product and Hg(0) collections, mercury deposition, and waterbody sediments; and has a fish consumption advisory. In addition, as part of the Willamette River TMDL development, Oregon has completed extensive modeling work and developed a mass balance model for mercury cycling.[125]

PENNSYLVANIA

The top intrastate mercury sources for the state are coal-fired EGUs, cement kilns, and municipal solid waste incinerators. Pennsylvania has a mercury automobile switch workgroup comprised of state agency staff, automobile recyclers and shredders, steel recyclers, mercury recyclers, and an environmental group. Additional elements of their mercury action plan include state regulations on mercury releases from WWTP facilities; case-by-case mercury emission limits required through air permits on new and minor emissions sources; and a voluntary collection programs used by schools, dental offices, farms, non-profits, and individuals.

Pennsylvania participates in the national MDN; monitors air emissions, ambient air, and deposition; conducts on-going fish tissue testing and sampling; and has a statewide fish consumption advisory due to mercury contamination. In 2006, Pennsylvania Governor Edward G. Rendell proposed a state-specific mercury reduction plan that would cut mercury emissions by at least 90% by 2015.[126]

WISCONSIN

The top mercury sources for Wisconsin are coal-fired EGUs, dental amalgam, and broken mercury-containing products and spills. The state has a Mercury Team comprised of key agencies including Health and Family Services, Agriculture, and Trade and Consumer Protection. Wisconsin received a GLNPO grant that funded a mercury collection project from 2001-2005. The following statutes, regulations and policies relate to the mercury action plan:

- State regulations on mercury releases from coal-fired EGUs and WWTP.
- Mandatory recycling of collected mercury; voluntary mercury collection programs for Hg(0), mercury waste, and mercury-containing products.
- Local clean sweeps and specific mercury reduction pilot programs from state or federal grants to subsidize mercury collection and recycling.
- Collection buckets, spill kits, and instructions provided to participating scrap yards.

In addition, the state has a cooperative effort with Auto and Scrap Recyclers trade association where those that participate in the voluntary removal of mercury switches from end-of-life passenger cars and trucks satisfy the mercury recovery component of their required stormwater management plan.

Wisconsin does on-going fish tissue testing and sampling, has a statewide fish consumption advisory, and are participants in the national MDN. In addition, they've been involved in the development of an atmospheric modeling system for the Great

[125] Oregon's mercury information is at http://www.deq.state.or.us/lq/mercury.htm.
[126] Pennsylvania's mercury reduction website is at http://www.pca.state.mn.us/air/mercury.htm.

Lakes Region and they conduct mercury monitoring of emissions, ambient air, wastewater discharge, mercury deposition, waterbody sediment, and wildlife.

5.4.2 NEW ENGLAND GOVERNORS/EASTERN CANADIAN PREMIERS (NEG/ECP)

The NEG/ECP, comprised of six states and five provinces, adopted a *Mercury Action Plan in 1998*. A regional Mercury Task Force was created to develop, implement, and report on regional progress that includes a work plan to identify priorities for action over the upcoming reporting cycle (since 2003, the reporting cycle has been completed every two years). Material contributors for these reports, coordinated by the Mercury Task Force, include state and provincial environmental agency staff, the three regional interstate organizations (NEWMOA for P2 and product-related issues; New England Interstate Water Pollution Control Commission for water related issues; and NESCAUM for air related issues), EPA, Environment Canada, the CEC and regional research organizations. The report is expected to be finalized in June 2007.

The mercury action plan documents a long-term goal of virtual elimination of anthropogenic emissions of mercury and a 50% reduction in regional emissions by 2003. NESCAUM and the Mercury Task Force determined this reduction based on inventories submitted by the states and provinces. The state inventories were developed by a workgroup comprised of air program staff and coordinated by NESCAUM. The provinces independently developed and submitted their inventories.[127]

Since the mercury action plan was adopted, the regional 50% target was exceeded with an estimated reduction of about 55% and a 75% reduction is expected by 2010. This success has been achieved through aggressive commitments and concerted regional cooperation and can be used as a template for the Great Lakes region to follow (Smith and Trip, 2005). In the mercury action plan, the NEG/ECP also agreed to implement regional strategies to promote the maximum economically and technically feasible reductions in mercury emissions from EGUs and other boilers in the region. In 2000, the NEG/ECP workgroup recommended a reduction in mercury emissions from coal-fired EGUs by 20% to 50% by 2005 and 60% to 90% reduction by 2010.[128] As of 2005, actual reductions were around 10% primarily due to fuel switching (high to lower mercury coals) in Connecticut.

The region representative noted that developing inventories is challenging as sources and emission data are constantly changing. Reductions in emission estimates that were solely due to improved emissions estimate data (rather than actual emission reductions) were not counted (e.g. the 1998 baseline inventory overestimated emissions from coal-fired EGUs in the region. The improved data that resulted largely from the EPA national and state testing programs to revise the baseline inventory for this sector was used rather than counting the lower estimate as a reduction). The Northeast states and provinces are now implementing regulations that substantially exceed the EPA CAMR (e.g. Massachusetts regulations require 85% control by 2008 and 95% by 2012) (Smith, 2007).

5.4.3 BI-NATIONAL TOXICS STRATEGY (BNS)

The BNS is the Canada-U.S. strategy for the virtual elimination of persistent toxic substances in the Great Lakes Basin. The BNS establishes reduction challenges for an initial list of persistent targeted toxic substances, including mercury. It provides a framework for actions to reduce or eliminate persistent toxic substances, especially

[127] The most current state inventory can be found at the NESCAUM website at http://www.nescaum.org/.
[128] The NEG/ECP Mercury Program website is at http://www.neg-ecp-environment.org/page.asp?pg=47.

those which bio-accumulate, from the Great Lakes Basin. ESSD and AQD staff participated regularly in biannual meetings to coordinate efforts and share ideas relating to mercury elimination with other state and federal and Canadian representatives. The future efforts of the BNS are unknown at this time.

The concept of virtual elimination has been incorporated into the EPA and Environment Canada's BNS and in the Lake Superior Bi-National Program for a number of years. To further the goals of the GLWQA, the Great Lakes Bi-National Toxics Strategy (GLBTS) was formed by U.S. and Canada in 1993. While there have been participants from the MDEQ involved in both the Lake Superior Bi-National Program and the GLBTS, there still exists somewhat of a disconnect between these policy efforts and the regulatory programs within which the MDEQ currently operates. The discussion that follows highlights some of these programs.

GREAT LAKES BI-NATIONAL TOXICS STRATEGY

The GLBTS was intended to develop a collaborative process toward the goal of virtual elimination of persistent toxic substances from the Great Lakes Basin.[129] The parties include Environment Canada, the EPA, the Great Lakes' states, the Province of Ontario, and Native American Tribes and First Nations, working in cooperation with public and private partners.

The goal of virtual elimination was to be achieved through a variety of programs and actions, with an emphasis on P2. It is a long-term objective, with the GLBTS providing a framework to achieve specific actions, beginning in 1997. PBTs comprise a list of Level 1 substances representing the primary focus of the GLBTS. Mercury is a Level 1 substance.

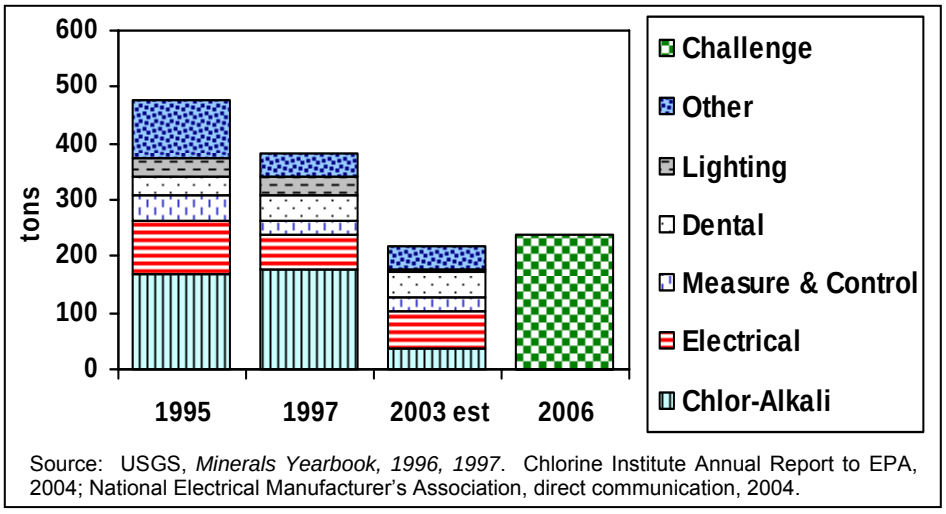
The BNS's release challenge applies to the aggregate of releases to the air nationwide, and of releases to the water within the Great Lakes Basin. The GLBTS acknowledges that the primary remaining source of mercury emissions in the Great Lakes ecosystem is atmospheric deposition. In the U.S., standards for municipal and medical waste combustors have been implemented; rules on controls of mercury from electric utility boilers are being developed; and controls on other point sources, such as chlor-alkali facilities (there are none currently located in Michigan, just chlor-alkali legacy sites) are also being developed and implemented.

The BNS's challenge to the U.S. is to seek by 2006 a 50% reduction nationally in the deliberate use of mercury, and a 50% reduction in the release of mercury from sources attributable to human activity (using the 1990 baseline inventory). The best available data indicates that significant progress is being made in reducing mercury releases, with a total estimated emissions reduction of 47% between 1990 and 2002 (**Figure 5-2**).

However, actual emissions reduction has likely been deeper than this estimate would indicate, because two of the biggest 2002 emissions source categories – EAFs and gold mining, are not included in the 1990 inventory. EPA is currently developing updated emissions estimates for these categories and the prospects are good that the U.S. has exceeded the 50% reduction challenge.[130] For mercury use, the best available data (shown in **Figure 5-3**) indicate that the challenge has already been achieved.

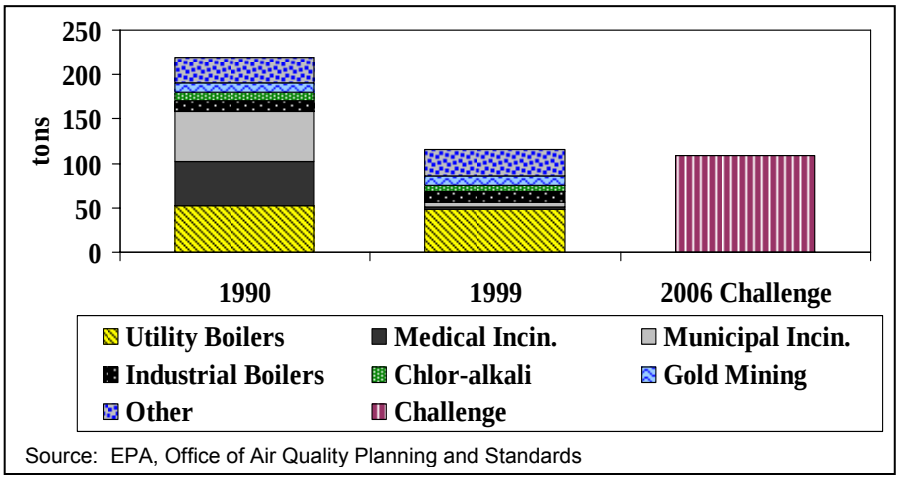
[129] Details on the Great Lakes Bi-National Toxics Strategy is at http://www.epa.gov/glnpo/bns/index.html.
[130] The Bi-National Strategy Mercury Progress Report is at http://www.epa.gov/region5/mercury/progress06.pdf.

FIGURE 5-2: U.S. MERCURY EMISSIONS - 2006 CHALLENGE, 1990 BASELINE



Source: USGS, *Minerals Yearbook, 1996, 1997*. Chlorine Institute Annual Report to EPA, 2004; National Electrical Manufacturer's Association, direct communication, 2004.

FIGURE 5-3: U.S. MERCURY USE



Source: EPA, Office of Air Quality Planning and Standards

The Canadian challenge was to seek a 90% reduction in the release of mercury (using 1988 baseline inventory), or where warranted, the use of mercury, from polluting sources attributed to human activity in the Great Lakes Basin. According to EPA's and Canada's *Great Lakes Bi-National Strategy 2005 Annual Progress Report*, Canadian progress toward the reduction of mercury releases into the Great Lakes Basin is well advanced and currently stands at 84%.[131] In the IJC's *12th Biennial Report on Great Lakes Water Quality*, (2004)[132] the IJC urged the governments of both nations to step up protection and restoration efforts. EPA has scheduled the next BNS meeting for December 12-13, 2007, in Chicago, Illinois.

LAKE SUPERIOR BI-NATIONAL PROGRAM

The virtual elimination of mercury has been a goal since 1987 in the Lake Superior Bi-National Program. In its *Fifth Biennial Report on Great Lakes Water Quality*, the IJC recommended that "the Parties designate Lake Superior as a demonstration area where no point source discharge of any persistent toxic chemical will be permitted." The EPA and Environment Canada announced that Lake Superior would be the focused area for

[131] The Great Lakes progress report is at http://binational.net/bns/2005/2005-GLBTS-English-web.pdf.
[132] The IJC 12th Biennial Report is at http://www.ijc.org/php/publications/html/12br/english/report/index.html.

virtual elimination in 1991. The Lake Superior Lake-wide Management Plan (LaMP) is used as a vehicle for delivering the 1991 Bi-National Program to Restore and Protect the Lake Superior Basin (i.e. the Lake Superior Bi-National Program). Reduction in existing releases has been secured both through voluntary P2 activities and enhanced control and regulatory efforts. The MDEQ staff has been involved in this effort since the early 1990s.[133]

The parties implementing the Lake Superior Bi-National Program decided progress will not be measured by changes in the fish, sediment, air or water; instead, changes would be measured by changes in the release of the chemicals and the products and services that use or generate them. The reduction goals for the Lake Superior Bi-National Program's LaMP Stage 2 Reduction Schedule are: 1990 (baseline), 2000 (60% reduction), 2010 (70% reduction), and 2020 (100% reduction). With a strive for zero discharge and beyond regulatory compliance, the guiding principles include:

1. Targets are applied basinwide and are not schedules for specific sources.
2. Staged reductions lead to the endpoint of zero discharge.
3. New or expanded sources will be incorporated into the source inventories.
4. Advocate the goal of zero discharge internally and externally.
5. Load reduction strategies include both P2 and regulation.
6. Out-of-basin sources add a significant load and need to be addressed.
7. In-basin solutions are preferred.
8. Actions taken to fulfill the load reduction schedules must be consistent with a sustainable economy.
9. Collaboration is needed since the objectives of the LaMP will not be reached without the active involvement of many others partners.
10. Outreach and education is needed for businesses, communities and individuals to accept the challenge of zero discharge.
11. The LaMP chemical chapter supports and is integrated with the other chapters of the LaMP as part of the Lake Superior Bi-National Program.

Some of Michigan's mercury reduction activities that have occurred in the Lake Superior Basin include:

- A number of voluntary stewardship programs where mercury reduction goals play a significant role. Among them are the Michigan Chapter of H2E, Michigan's Clean Corporate Citizen Program, Michigan Business Pollution Prevention Partnership, Michigan Pulp and Paper Pollution Prevention (P5) Program, and several others. As just one example, Mercury Minimization Plans were set as an industry-wide goal for all P5 partners during 2004. The 10 participating paper mills, which account for approximately 70% of Michigan's paper production, have all performed system-wide mercury audits or inventories and pledged to eliminate mercury-containing devices as they are retired or taken out of service. New members joining the P5 Program in the future will be expected to do the same.
- The MDEQ provides a number of non-regulatory assistance and information programs which emphasize P2 to help the citizens and businesses of Michigan make informed decisions and take actions that conserve resources and prevent pollution and waste.[134] The ESSD has field staff assigned to each MDEQ district office to serve as a focal point for P2 assistance.

[133] View EPA's latest Bi-National Program status report at http://www.epa.gov/glnpo/bns/meetings/may2002/IJC%20Presentation2%20Sept%202001%20(2).pdf.
[134] Visit http://www.michigan.gov/deq/0,1607,7-135-3585-115473--,00.html for a list of P2 programs.

- In 2005, Marquette County Solid Waste Management Authority removed over 75,000 lbs of toxic/hazardous material from the waste stream. These materials included HHW such as mercury (40 lbs were removed), volatile organic compounds, and poisons.
- The Superior District Dental Society (Marquette, MI) working with the Central Lake Superior Watershed Partnership and the Marquette WWTP, passed a resolution to voluntarily install mercury amalgam separators. The Dental Society represents 58 dental offices in Marquette and Alger County.
- The MDEQ has partnered with the DLEG Energy Office, MPSC, and Department of Transportation to identify various energy efficiency and energy conservation programs and resources available to the public, private business, and municipal government. Energy efficiency plays an important role in P2 and environmental sustainability in Michigan.

5.4.4 GREAT LAKES REGIONAL COLLABORATION (GLRC)

The Governors of the Great Lakes States identified priorities for restoring and protecting the Great Lakes, supported by the Great Lakes and St. Lawrence Cities Initiative, the Great Lakes Commission, and other entities committed to the preservation of the Great Lakes. EPA and nine other federal agencies administer some 140 programs that fund and implement environmental programs in the Great Lakes Basin. Although there has been significant progress, the work of cleaning up the lakes and preventing further problems has not always been coordinated.

While certain persistent toxic substances have been significantly reduced in the Great Lakes Basin Ecosystem over the past 30 years, there is a legacy of contamination in sediments and fish throughout the system, and mercury and other pollutants continue to enter the Great Lakes from nearby and distant sources. Toxic releases from contaminated bottom sediments, various industrial processes, and non point sources, loadings from atmospheric deposition, contaminated groundwater, and continuous cycling of PBTs within the Great Lakes themselves all contribute to this ongoing problem. While large amounts of data and information on the Great Lakes have been collected over the years, not enough of that has been transformed into knowledge about the key indicators of the health of the ecosystem. Characteristics of these substances, such as sources, releases, fate, transport, persistence, bioaccumulation, and toxicity, must be better understood.

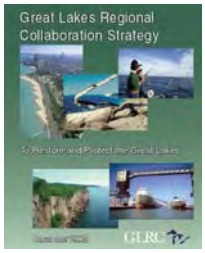
In May 2004, President Bush issued an Executive Order creating the federal Great Lakes Interagency Task Force to promote a "Regional Collaboration of National Significance" for the Great Lakes. Members of the federal Great Lakes Interagency Task Force, the Council of Great Lakes Governors, the Great Lakes and St. Lawrence Cities Initiative, Great Lakes tribes (represented by the Great Lakes Indian Fish and Wildlife Commission) and the Great Lakes Congressional Task Force convened a group known as the Great Lakes Regional Collaboration (GLRC).

The GLRC held its first conveners meeting on December 3, 2004, where they developed the Great Lakes Declaration and the framework defining the process for developing a GLRC Strategy.[135] Following the conveners meeting, some 1,500 people from throughout the Great Lakes Basin participated on eight Issue Area Strategy Teams, each focusing on a different issue affecting the Great Lakes Basin. These teams were organized around eight of the nine priorities established by the Council of Great Lakes Governors in October 2003. The work of the strategy teams includes

[135] Information on the Great Lakes Regional Collaboration Strategy is at http://www.glrc.us/strategy.html.

many recommendations for action, focusing on the steps that should be taken over the next five years to proceed with restoration to achieve the greatest results. A number of the key recommendations crafted by the strategy teams (not an exhaustive list) include:

- Major improvements in wet weather discharge controls from combined and sanitary sewers, and identify and control releases from indirect sources of contamination.
- A dramatic acceleration of the cleanup process at those areas of concern (AOC) identified in 1987 under the GLWQA.[136]
- Actions to address non point sources of pollution (e.g., wetland restoration), as these sources contribute significantly to problems in the AOC, as well as other locations in the Great Lakes.
- **Reduce and virtually eliminate the discharge of mercury** (emphasis added) and other toxic substances to the Great Lakes; institute a comprehensive research, surveillance and forecasting capability; create consistent, accessible basin-wide messages on fish consumption and toxic reduction methods and choices; and support efforts to reduce continental and global sources of toxics to the Great Lakes (see **Toxic Pollutants Initiative**).
- Have a sound information base and representative indicators to understand what is happening in the Great Lakes Ecosystem which must be communicated to the public, decision makers, and all other involved. Actions include establishing a regional information management infrastructure and creating a Great Lakes communications workgroup to manage scientific and technical information.
- Ensuring the long term sustainability of the Great Lakes resource will require a number of significant changes in the way we approach such things as land use, agriculture and forestry, transportation, industrial activity, and many others.



The strategy teams developed the recommendations that form the basis of the report titled, "*Great Lakes Regional Collaboration Strategy to Restore and Protect the Great Lakes*," released on December 12, 2005, which calls for the continued reduction and virtual elimination of persistent toxic substances such as mercury in the basin. [137]

Toxic Pollutants Initiative: The GLRC began development of a Toxic Pollutants Initiative that set forth a series of near term activities to implement the GLRC's recommendations.[138] This initiative uses the existing Great Lakes Bi-National Toxics Strategy as the starting point and builds on the efforts of the LaMPs to help implement lake-specific high priority chemical reduction efforts and on recommendations from remedial action plans to address beneficial uses impaired by toxics in the AOC. Proposed activities of the Toxic Pollutants Initiative includes creating a mercury in products phase-down strategy, mercury emission reduction initiative, several education and outreach campaigns (burn barrel and pharmaceutical and electronic waste disposal), and a great lakes sport fish consortium project. The following is a brief discussion of these activities:

- **Mercury in Products Phase-Down Strategy** - In 2006, a workgroup comprising state, tribal, and cities initiative staff was formed to develop a basin-wide strategy

[136] Information on the Great Lakes AOCs can be found at http://www.epa.gov/glnpo/aoc/index.html.
[137] Information on the Great Lakes Regional Collaboration Strategy is at http://www.glrc.us/strategy.html.
[138] Information on the Toxic Pollutants Initiative is available at http://www.glrc.us/initiatives/toxics/index.html.

for the phase-down of mercury in products and waste. The *Great Lakes Mercury Phase-Down Strategy* seeks to complement and enhance the recommendations in the QSC's Action Plan and Implementation Strategy for reducing mercury in the environment. The strategy identifies full phase-outs of mercury-added products by 2015, as possible, as an interim milestone for toxics reduction. Some states, tribes and cities in the Great Lakes Basin have passed laws or have implemented programs to prevent pollution from mercury-containing products. This strategy seeks to build on those foundations to accomplish the 2015 phase-down goal. The strategy recommends a wide range of product-targeted policies for states to adopt, including sale bans and phase-outs, disposal regulations, public awareness and education programs, collection/end-of-life management for products, purchasing preferences, and labeling requirements. Some will require legislative action; others can be implemented by state, municipal or tribal agencies. Implementation of this strategy is one important element in achieving virtual elimination of mercury inputs into the Great Lakes as envisioned in the Great Lakes Bi-National Toxics Strategy. The draft *Great Lakes Mercury Phase-Down Strategy* was made available for public comment through October 27, 2007. Comments received during the public comment period are now being considered.[139]

- **Mercury Emission Reduction Initiative** –A Great Lakes mercury emission reduction initiative includes the development of a region-wide strategy for reducing mercury in products in a manner similar to the *Great Lakes Mercury in Products Phase-Down Strategy* discussed above. This effort should produce institutionalized activities to sustain mercury emissions reduction from new and existing sources whose mercury emissions have not been regulated, and from sources where regulations have been implemented but additional reductions are technically feasible and economically reasonable. The proposed schedule for developing a mercury emission reduction strategy would include:
  - Initial teleconference to discuss mission and goals (held in October 2007).
  - Conference call with Bi-National Toxics Strategy mercury workgroup to discuss work plan and opportunities for input (held in December 2007).
  - Draft an evaluation of the major sources of mercury deposition in the Great Lakes region and a list of priority sectors to include in the strategy, based on amount of emissions within the Great Lakes states and current availability of measures to achieve reductions. Also identify sectors for future work (February 2008).
  - Distribute for technical and limited public review through Bi-National Toxics Strategy mercury workgroup (March 2008).
  - Develop draft strategy, including recommended actions (May 2008).
  - Distribute for technical and limited public review through the Bi-National Toxics Strategy mercury workgroup (May 2008).
  - Revise draft strategy (August 2008).
  - Release draft strategy for general public comment (August-October 2008).
  - Revise draft strategy based on public comments (October-December 2008).
  - Complete GLRC membership review of final strategy (January 2009).
  - Release final draft and begin implementation of recommendations (March 2009).

[139] Responses to comments received are available for review at http://www.glrc.us/documents/MercuryStrategyResponsetoStakeholderComments.pdf.

- **Burn Barrel Education and Outreach Campaign -** EPA with Great Lakes states, tribes, and cities are collaboratively developing an education and outreach program to address open burning across the Great Lakes Basin. This project targets local and tribal waste management officials to provide education about environmental concerns associated with trash burning, information on infrastructure and alternatives to burning in communities, and tools to strengthen state, tribal and local ordinances on burning and support greater compliance with current regulations. At the end of 2007, staff will present the outcomes at statewide meetings that will be held in all of the Great Lakes states.
- **Pharmaceutical and Electronic Waste Disposal Education and Outreach Campaign** - Similar to the burn barrel campaign above, this campaign will target state, tribal and local waste management officials to provide information about pharmaceutical and electronic waste disposal and recycling policies and options. Toolkits have been developed that provide information on health and environmental concerns associated with these wastes; current federal, state and local regulations governing recycling and disposal; examples of take-back programs and other success stories; and, a list of resources. Through 2007, Illinois and Indiana Sea Grant staff are attending a series of statewide meetings to present and provide the toolkits. Outcomes will include collection and/or recycling activities implemented as a result of the campaign, pounds of pharmaceuticals collected and safely disposed, and pounds of E-waste recycled and/or safely disposed.
- **Great Lakes Sport Fish Consortium Project** – The Great Lakes Sport Fish Consortium (via the Wisconsin Department of Health and Family Services with representatives of all Great Lakes states and tribes) has been funded by EPA to finalize a basin-wide uniform mercury protocol for sensitive populations. This project, taking into consideration the needs of subsistence and commercial fishermen, will develop new fish consumption outreach materials related to mercury. To create an economy of scale, one grantee will develop the materials based on a goal of state consensus. In turn, the states will be able to use materials for outreach. By the end of 2007, a final draft protocol will be produced. Basin-wide outreach materials will be produced by the end of 2008. Outcomes will include advisories issued based on the protocol.

5.4.5 COMMISSION FOR ENVIRONMENTAL COOPERATION'S (CEC'S) NORTH AMERICAN REGIONAL ACTION PLAN (NARAP) FOR MERCURY

The CEC is a trinational organization established under the North American Agreement on Environmental Cooperation (NAAEC) that has highlighted the importance of "cooperation on the conservation, protection and enhancement of the environment in [the] territories" of Canada, Mexico and the U.S. As a parallel side agreement to the NAFTA, the North American Regional Action Plan (NARAP) on Mercury is one of a number of such regional undertakings that stem from the NAAEC. Mercury, as well as chlordane, DDT (dichlorodiphenyltrichloroethane), and PCBs, was identified as one of four priority toxic substances mandated under the CEC for action plan development. The purpose of the mercury NARAP is to provide the governments of Canada, Mexico, and the U.S. with a path forward "to reduce the exposure of North American ecosystems, fish and wildlife, and especially humans, to mercury through prevention and reduction of anthropogenic releases of mercury to the North American environment."

On March 16, 2000, the *NARAP on Mercury, Phase II Report* was released that established an ultimate goal of reducing inputs of mercury to the environment to

naturally-occurring levels with an interim target of 50% or greater by 2006. Included in the report were the following general objectives:[140]

> ***General Ambient Mercury Objective:*** Reduce mercury levels in, and fluxes among, selected indicative environmental media in order to approach natural levels and fluxes, thereby preventing or minimizing exposure of North American ecosystems, fish and wildlife, and humans to levels in excess of those that can be attributed to naturally occurring levels and fluxes of mercury in environmental media.
>
> ***General Mercury Release Objective:*** Recognizing that mercury is a naturally occurring element that can never be eliminated from the environment, reduce, or, when warranted, target for reduction through a life cycle management approach, the sources of anthropogenic mercury pollution so as to achieve naturally occurring levels.
>
> ***General Mercury Use Objective:*** Recognizing the requirement to prevent or minimize releases of mercury used in commerce within the North American economy, consider initiatives such as promotion and use of products and technologies that pose less risk than those used at present.[141] Facilitate product stewardship, product labeling, extended product responsibility, use limitations, economic incentives, recycling, and, where there is an unreasonable or otherwise unmanageable risk of release to the environment or risk to human health, phase-out or ban specific mercury uses.

There were several concerns expressed regarding the degree to which the recommendations in the plan may be implemented and that the voluntary/nonregulatory actions may not be adequate to substantially reduce mercury use and release. To ensure that the actions outlined in the mercury NARAP are carried out, the CEC has directed the Sound Management of Chemicals Working Group to oversee an Implementation Task Force. It is anticipated that through a strong national commitment to action, the mercury NARAP will result in significant reductions of mercury contamination to the environment.

5.4.6 UNITED NATIONS ENVIRONMENTAL PROGRAM (UNEP)

The United Nations is addressing mercury at the global level through the UNEP. The UNEP's mission is

> "to provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations."

In 2001, the UNEP Chemicals decided to develop a global assessment of mercury and its compounds, including an outline of options for addressing any significant global adverse impacts of mercury. In 2002, the UNEP present its report titled, "*Global Mercury Assessment Report*," to the UNEP Governing Council[142] This report provided the basis for the Governing Council in February 2003 to conclude:

> "that there is sufficient evidence of significant global adverse impacts from mercury to warrant further international action to reduce the risks to humans and wildlife from the release of mercury to the environment (UNEP, 2003)."

[140] The NARAP report is at http://www.cec.org/programs_projects/pollutants_health/smoc/smoc-rap.cfm?var.
[141] This Phase II amendment to the original Action Plan reaffirms the direction provided in Resolution 95-05.
[142] This 2002 UNEP report is at http://www.unep.org/civil_society/GCSF8/pdfs/mercury_ass_rep_eng.pdf.

The Governing Council also urged all countries to adopt goals and take national actions, as appropriate, with the objective of identifying exposed populations and ecosystems. In addition, an action plan was agreed upon to assist all countries, especially developing countries and countries with economies in transition, to cut their emissions and releases of mercury. Beginning in 2004, mercury awareness seminars were held at the following locations:

- Bangkok, Thailand (April 2004)
- Pretoria, S. Africa (June 2004)
- Kiev, Ukraine (July 2004)
- Buenos Aires, Argentina (September 2004)
- Beirut, Lebanon (October 2004)
- Dakar, Senegal (November 2004)
- Port of Spain, Trinidad and Tobago (January 2005)

Up to 21 different countries have attended these seminars along with a number of other invited experts, Inter-Governmental Organizations (such as the World Bank and Basel Convention Regional Centers in Indonesia and China) and Non-Governmental Organizations (such as the Ban Mercury Working Group, the Natural Resource Defense Council, and the Electric Power Research Institute [EPRI]).

In February 2005, the Governing Council adopted an omnibus decision that established partnerships between Governments and other stakeholders to take action regarding mercury pollution. Also included in this decision was a request for the UNEP to develop a report on the supply, trade, and demand for mercury on the global market, and, based on a consideration of the life-cycle approach, form a basis for consideration of possible further actions. [143] The following five areas were identified for partnership development:[144]

1. Chlor-alkali sector,
2. Coal combustion,
3. Mercury-containing products,
4. Small scale artisanal gold mining and
5. Mercury air transport and fate research.

In November 2005, the UNEP released a toolkit for identification and quantification of mercury releases that is a key training and guidance document supporting countries efforts to take action on mercury.[145] In April 2006, UNEP was successful in raising some limited funding to support partnership activities and implementation projects at national or regional levels.

In summary, priority activities of the UNEP mercury program in 2005/2006 established in response to UNEP Governing Council have been to:

- raise awareness of the nature of mercury pollution problems, through regional awareness-raising workshops and assisting countries to identify, understand and implement actions to mitigate any mercury problems in their countries;
- develop guidance materials and toolkits;
- develop a clearinghouse for mercury-related information, with relevant information distributed via internet as well as other media; and
- support governments and other stakeholders to develop and implement partnerships, in a clear, transparent and accountable manner.

[143] Trade information on mercury is at http://www.chem.unep.ch/mercury/Trade-information.htm
[144] Progress reports are available at http://www.chem.unep.ch/mercury/partnerships/default.htm
[145] The UNEP toolkit is at www.unep.org/civil_society/GCSF8/pdfs/UNEP-final-pilot-draft-toolkit-Dec05.pdf.

6. ENVIRONMENTAL MONITORING

Much of this information is taken from what was written by MDEQ staff for the Michigan's Mercury Electric Utility Workgroup report finalized June 20, 2005 and has been updated where necessary.

The atmosphere has been determined to be the most significant source of mercury contribution to Michigan's lakes, although the environmental mobilization of mercury from mining and local geological sources is considered an important source to lakes in the U.P. of Michigan. The MDEQ routinely monitors for mercury in surface water, drinking water, and fish. Monitoring of sediments, air and biota are typically only conducted if grant monies are available.

6.1 AIR QUALITY DIVISION (AQD)

The AQD conducts very limited monitoring for mercury. There is no budget allocation for mercury monitoring, therefore the monitoring that has been conducted is the result of state and/or federal grants.[146]

6.1.1 FUGITIVE MONITORING

TRI-STATE MERCURY MONITORING PROJECT

The Great Lakes' states of Michigan, Minnesota, and Wisconsin face similar challenges regarding mercury contamination of the environment. In an effort to identify and quantify under-appreciated sources of mercury to the atmosphere, the three Great Lakes' states jointly applied for and received grant funding from the EPA in 2000.

The MDEQ was responsible for administering the funds which included the design and building of a mobile mercury laboratory, housed in a climate-controlled trailer, complete with a generator, two Tekran 2537A mercury vapor analyzers, meteorological monitoring equipment, data loggers, and a computer for data compilation and analysis. The mobile laboratory has been and will continue to be shared among the three states for data collection.

The EPA funding also allowed for the purchase and sharing of two Lumex RA 915+ mercury vapor analyzers for the identification of mercury sources. The Lumex is at least an order of magnitude less sensitive than the Tekran devices, but is much more portable and quicker to yield data. In general, the Tekran has been found to be useful for precise and accurate quantification of subtle differences in mercury concentration outdoors or in clean indoor environments. In contrast, the Lumex devices are useful for identifying relatively large mercury sources, spills, and indoor contamination.

The three states continue to use the equipment to quantify mercury releases from manufacturing facilities (thermometers, chlor-alkali), mercury recyclers (fluorescent bulbs and other materials), scrap metal yards and shredders, solid waste processing facilities, medical waste autoclaves, land-applied wastes (sewage sludge, wood ash, coal ash), and taconite tailing basins. In addition, Michigan, Minnesota, and Wisconsin have all assisted local health departments in providing use of the Lumex instruments to facilitate quantification of mercury concentrations in homes or businesses where

[146] Excerpts for this section were taken from the Michigan Mercury Utility Report, 2005.

mercury was spilled. The final grant report titled, "*Identification of Atmospheric Mercury Sources in the Great Lakes States through an Ambient Monitoring Program*," was finalized in November 2003.[147]

The MDCH and the following county health departments now have their own mercury vapor analyzers (or share one among their district) due to various funding sources and/or agreements (see **Chapter 2.6.3** for complete location information): Bay, Central Michigan District Health Department (Arenac, Clare, Gladwin, Isabella, Osceola, and Roscommon Counties), Genesee, Ingham, Isabella, Kalamazoo (who shares with Kent County), Macomb, Marquette, Northwest Michigan Community Health Agency (Antrim, Charlevoix, Emmet, and Otsego Counties) Oakland, Saginaw, Wayne, and the Western U.P. District (Baraga, Gogebic, Houghton, Keweenaw, and Ontonagon Counties).[148] Some monies were allocated from SEPs for the purchase of Lumex monitors for the county environmental health departments.

The 2537A Tekran units were deployed in 2006 to 2007 in Grand Rapids and Holland to obtain additional Hg(0) data in west Michigan. Data gathered will continue to be reported and posted on the AQD web site.

ATMOSPHERIC MERCURY MONITORING ACTIVITIES, JULY 2005

In addition to partnering with Minnesota and Wisconsin, the AQD also partnered with Oak Ridge National Laboratory from 2003-2005 under a grant entitled *Fugitive Mercury Emissions from Noncombustion Sources in the Great Lakes Region* (FuME). This grant sought to collaborate between the three states to facilitate further identification of fugitive mercury emissions. Studies were conducted in Michigan to assess the fugitive releases of mercury from a variety of sources including a thermometer manufacturer, automobile shredders, and a fluorescent light recycler.[149] The following information discusses the results from a fluorescent lamp drum-top crusher:

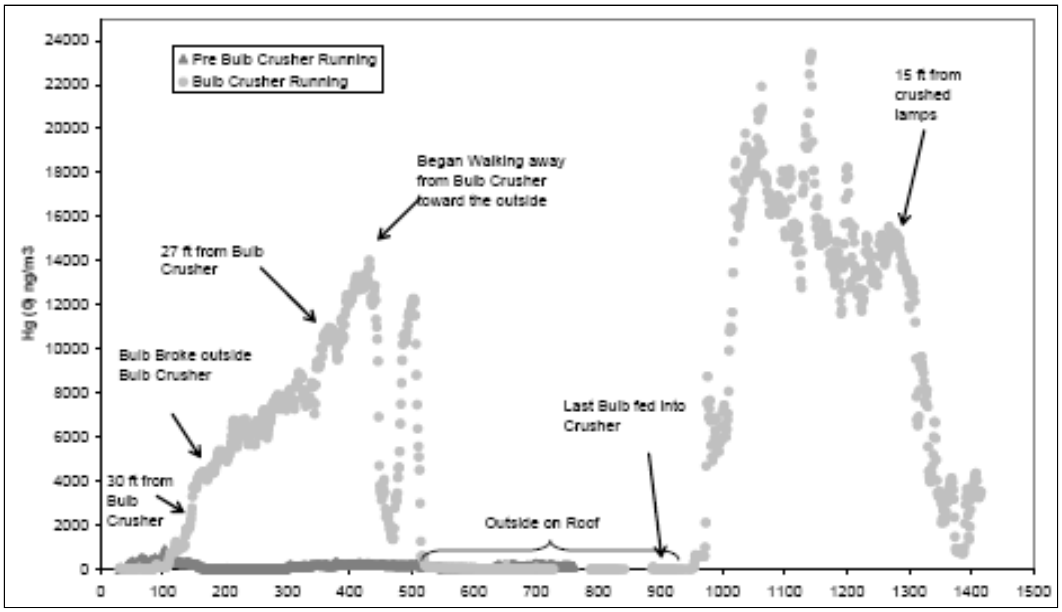
DRUM-TOP FLUORESCENT BULB CRUSHER: The Ingham Regional Medical Facility (IRMF): is a hospital in Lansing that operates a drum-top fluorescent bulb crusher that could potentially release unacceptable levels of Hg(0) vapor and possibly cause expensive contamination of its surroundings. At the time of the Oak Ridge National Laboratory and AQD staff visit (July 19, 2005), IRMF had been operating a Bulb Eater manufactured by Air Cycle Corporation for approximately two years. This unit consisted of a drum-top mounted lamp crusher and a 55-gallon drum used to collect crushed material (shown at right). Exhaust from the unit passed through a filter bag, HEPA filter, and activated carbon filter (laced with 15% yellow sulfur) before exiting to the ambient air. IRMF operated their Bulb Eater in a poorly ventilated room and when in use, the collection chamber on the crusher was under negative pressure with an air flow of 40 cubic foot per minute (cfm). The feed chute for straight lamps had a screw-on cap to prevent fugitive emissions when the unit was off. The Bulb Eater was not equipped with a lamp counter system, mercury monitoring system, nor warning indicators for filter changes or full barrels. It was up to the operator to track the number and type of lamps crushed to determine when

[147] The report is available at http://www.deq.state.mi.us/documents/deq-aqd-toxics-Hgfinalreport.pdf.
[148] Wayne County Health Department does not own one per se, but is able to borrow a Lumex from several Detroit Area industry businesses. The Tuscola County Health Department received one under a SEP agreement but decided to give their Lumex to the Western U.P. District Health Department.
[149] The AQD's Atmospheric Mercury Monitoring Activities, July 2005 report is available at http://www.michigan.gov/documents/deq-aqd-toxics-July_2005_Merc_Mon_Rpt_158779_7.pdf.

the carbon filters needed replacing. IRMF employees changed the filter bag when the drum was half full and again when the drum was full, and the HEPA filter was changed every 10 full drums. According to the manufacturer, the activated carbon mercury filter is rated for over 1,000,000 lamps. IRMF fed a mixture of both old and new lamps to its Bulb Eater and crushed about one box (36 bulbs) per day. For demonstration purposes, ~3 boxes (between 180-200 bulbs) were crushed while the Lumex analyzer was utilized to measure Hg(0) concentrations in the ambient air inside the room and on the roof immediately adjacent to the room.

As shown in **Figure 6-1**, significantly elevated concentrations of Hg(0) were detected inside the room when the crusher was operating, especially after a bulb was broken outside of the crusher. The mean Hg(0) concentration of the room before the Bulb Eater was operating was 156 ng/m^3. Depending on where Lumex monitoring was being conducted within the room, concentrations of Hg(0) ranged from ~5 ng/m^3 to ~901 ng/m^3. When the Bulb Eater was running and crushing bulbs, the Hg(0) concentration in the room steadily rose up to values around 13,000 ng/m^3. Outside on the roof directly adjacent to the crushing room, mercury concentrations were typical background levels with a Hg(0) mean concentration of 1.24±12.12 ng/m^3.

FIGURE 6-1: LUMEX MONITORING OF A DRUM-TOP FLUORESCENT LAMP BULB CRUSHER



Monitoring in the crushing room after the last bulb was fed into the crusher and the crusher had stopped operating yielded concentrations of ~15,000 ng/m^3. Concentrations of Hg(0) in the air directly next to the drum crusher may have been greater, but a distance of at least 15 feet from the drum crusher was maintained so the Lumex would not exceed its maximum detection limit and require an expensive cleaning. For comparison's sake, the NIOSH set its recommended exposure limit for mercury vapor at 0.05 milligram per cubic meter (50,000 ng/m^3). This recommended limit allows for up to a 10-hour workday for a 40-hour work week (NIOSH, 2005).

One confounder to these measurements is that one lamp was accidentally broken outside of the drum crusher. However, according to the operator, a lamp could be dropped and broken during normal operation of the crusher so these measurements should be viewed as being part of a normal activity.

Because of the potential release of Hg(0) from drum crushers, the AQD developed a general air permit for fluorescent light drum crushers (see **Appendix S**).[150] The EPA has also released a report titled *Mercury Lamp Drum-Top Crusher Study* that provides current information on the performance of drum-top mercury lamp crushing devices. The EPA believes that with this information, states, users of mercury-containing lamps, and lamp recyclers will be able to make more informed decisions when managing fluorescent lamps.

6.1.2 DEPOSITION MONITORING

Atmospheric deposition of mercury to the environment occurs when atmospheric mercury deposits to land or water through wet deposition or dry deposition or flux events (gas exchange). Mercury flux can occur when Hg(0) crosses the air/surface interface with soil, vegetation or water, and if the flux is down it is considered deposition, if it up it is considered evasion. Therefore, flux can be bidirectional.

> **Dry deposition** occurs continually except during periods of rainfall and can contribute a significant amount of mercury to aquatic, marine, and terrestrial ecosystems. Dry deposition can occur through direct deposition of gas phase Hg(0) and RGM and to a lesser extent deposition of atmospheric particles containing Hg. Vegetation can enhance dry deposition due to stomatal uptake (Lindberg et al., 1992; Lindberg et al., 2007).

Currently, there are very limited measurements of dry deposition of mercury anywhere in the world. This is largely due to the difficulty in performing these measurements and the cost of obtaining a long-term database for this purpose. Measurements of ambient mercury concentrations have been performed that suggest strong gradients in the levels of Hg(p) as well as for RGM. These gradients would imply similar gradients in the dry deposition fields, but to date only limited data have been obtained for testing this assertion. Using the dry deposition measurements that have been made, it has been estimated that dry deposition can be at least as significant as wet deposition and in some cases can exceed the contribution from wet deposition (Keeler and Dvonch, 2005; Lindberg et al., 2007).

> **Wet deposition** of mercury occurs when mercury is washed out of the atmosphere during rainfall or snowfall events. The primary mechanisms for wet deposition are in-cloud oxidation of Hg(0) by ozone and the gas-phase oxidation of Hg(0) by hydroxide and ozone followed by cloud-droplet uptake. Hg(p) can also contribute to wet deposition and wet deposition can also be enhanced by sources of RGM and Hg(p). The dominant form of mercury in wet deposition is dissolved mercury and Hg(p) with a small percentage (< 2%) of MeHg (Lindberg et al., 2007).

There is a significant amount of data available for wet deposition of mercury. Mercury deposition in the U.S. and Canada has been monitored for nearly a decade through the national Mercury Deposition Network (MDN), which is a sub-network of the National Atmospheric Deposition Program (NADP)/National Trends Network.[151] The MDN involves monitoring mercury concentrations and total mercury deposition through integrated, weekly, wet-only sampling. The data can be used to examine spatial and temporal trends in mercury deposition (MDN, 2004). A discussion of the MDN data can be found in the "*Scoping Study for Mercury Deposition in the Upper Midwest*," (Seigneur

[150] The monitoring report is also available at http://www.michigan.gov/documents/deq-aqd-toxics-July_2005_Merc_Mon_Rpt_158779_7.pdf.
[151] Information on the MDN can be found at http://nadp.sws.uiuc.edu/mdn/.

et al., 2003).[152] There is a current effort underway to expand the network to include dry deposition.

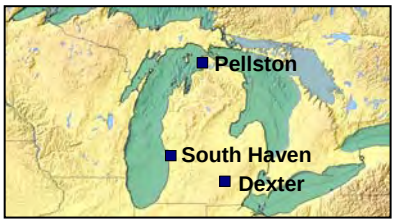
In 2003 and 2005, two national MDN sites began monitoring in Michigan for mercury wet deposition.[153] These sites, one in Michigan's U.P. and one in the Lower Peninsula (L.P.) (respectively), are located at the Seney National Wildlife Refuge, run by the Fish and Wildlife Service, and in Sterling Heights (Macomb County), sponsored by the U.S. Geological Survey (USGS) and run by the Macomb County Health Department. Starting in May 2007, a third MDN site began monitoring for mercury wet deposition in Michigan's Leelanau County, located in the upper half of the L.P.

DEPOSITION MONITORING IN MICHIGAN

Since 1992, several Michigan event-based wet deposition sites have been in operation (longest of any sites in the nation) by the U of M Air Quality Laboratory under the direction of Dr. Gerald Keeler. Collection of precipitation on an event basis is important for receptor modeling and meteorological analysis (Burke et al., 1995; Dvonch et al., 1999; Landis and Keeler, 1997). Until recently, this has been the only mercury deposition monitoring being conducted in Michigan. Due to lack of funding it is expected that in the near future these Michigan event based sites will no longer be running. The following provides information on deposition monitoring that has been done in and around the state of Michigan.

1992-1994: Starting in March 1992, under the direction of Dr. Keeler, event precipitation samples were collected for two years at three Michigan sites (**Figure 6-2**): South Haven, Pellston, and Dexter (Keeler and Hoyer, 1997). These sites were chosen to investigate spatial gradients and seasonal patterns in the concentration of mercury in precipitation. Daily event sampling was performed to allow investigation of meteorological and source influences at each site.

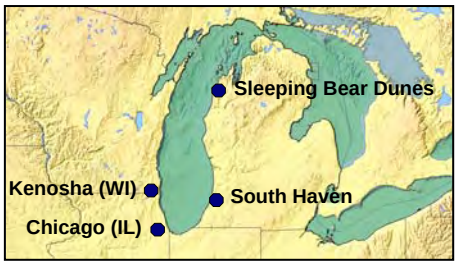
FIGURE 6-2: MERCURY WET DEPOSITION STUDY SITES FROM 1992-1994



A spatial gradient in the wet deposition of mercury from the southern part to the northern part of the L.P. was observed, with South Haven receiving 1.6 to 2.3 times more mercury deposition than Pellston in the two respective years of sampling. While the spatial differences in mercury wet deposition are clearly a function of the different amounts of precipitation received, the difference in mercury concentration between the sites also contributes substantially to the regional gradient in wet deposition. The mercury concentration in event precipitation varied by season with mercury concentrations two times greater during spring and summer months than during winter. The majority of the mercury deposition measured at the sites in spring and summer was associated with transport from the southwest (e.g., Chicago and Indiana area). However, at both Pellston and Dexter, transport from the northwest contributed a significant fraction (22%) of the mercury wet deposition. This finding is consistent with back trajectory models demonstrating that point sources of mercury in Michigan contribute to the deposition measured at Dexter and sources in the U.P. of Michigan, as well as Canada contributing to mercury deposition measured at Pellston (Keeler and Hoyer, 1997). [154]

[152] This study is available at http://www.ladco.org/toxics/reports/Mercury%20Scoping%20Study.pdf.
[153] Michigan site information is at http://nadp.sws.uiuc.edu/sites/sitemap.asp?net=mdn&state=mi.
[154] This data has been further evaluated which demonstrates the previously published data underestimated deposition collected at these sites from 1992-1994 (with the exception of 1994 Dexter data) (Keeler, 2007).

FIGURE 6-3: LMMBS SITES



1994-1995: The relative impact of the Chicago/Gary urban area on the ambient levels and deposition of mercury in the Lake Michigan basin was investigated as part of the Lake Michigan Mass Balance Study (LMMBS) and the Atmospheric Exchange Over Lakes and Oceans Study. As part of the LMMBS, **Figure 6-3** shows where event wet-only precipitation, total particulate, and vapor phase samples were collected for mercury and trace element determinations from four sites around Lake Michigan from July 1994 through October 1995. In addition, as part of the Atmospheric Exchange Study, intensive over-water measurements were conducted aboard the EPA research vessel Lake Guardian during the summer of 1994 and winter of 1995.

Atmospheric mercury concentrations were found to be significantly higher on average in the Chicago/Gary urban area than surrounding sites: mercury in precipitation was a factor of two and Hg(p) was a factor of seven-fold higher. Over-water measurements found elevated mercury concentrations 19 kilometers (km) offshore of Chicago/Gary suggesting an enhanced near field atmospheric deposition to Lake Michigan. A meteorological transport analysis also determined that local sources in the Chicago/Gary urban area significantly impacted all of the LMMBS sites indicating a broad impact to the entire Lake Michigan basin (Landis et al., 2002). These results support the previous study performed in Michigan (Keeler and Hoyer, 1997), which reports that the highest mercury concentration and deposition events occurred with transport from the southwest to the South Haven, Michigan site. The relative mercury deposition contribution from urban areas such as Chicago was not the only significant finding of the LMMBS. For example, the report found that each year Lake Michigan receives a total of approximately 1,403 kilogram (kg) (3,093 lbs) of mercury, of which approximately 84% enters the lake through direct atmospheric deposition. This study in both Chicago as well as a study in south Florida found as much as two-thirds (2/3) of the mercury wet deposition to be of a local anthropogenic origin (Landis and Keeler, 2002; Dvonch et al., 1999). Since the completion of the LMMBS, mercury sampling in Michigan has continued at several sites across the state.

1996: A Detroit study was funded by the Detroit WWTP in 1996 to ascertain, in part, the atmospheric contributions of mercury in urban runoff (Gildemeister, 2001). This study collected dry deposition data at several sites in Detroit using surrogate surfaces, and revealed large spatial gradients in Hg(p) deposition. The dry deposition of mercury was found to be comparable to the wet deposition measured concurrently over the seven-month study (10.2 microgram per square meter [$\mu g/m^2$] versus 14.8 $\mu g/m^2$, respectively). It is anticipated that the total dry deposition flux due to both Hg(p) and RGM would have been greater than the wet deposition flux, based upon the flux measurements performed in Chicago which suggested that about 52% of the dry deposition was due to Hg(p) (Landis and Keeler, 2002). While it was evident that urban sources were impacting mercury deposition to downwind lakes and ecosystems, studies performed to date have been limited by the lack of RGM measurements. The RGM data is essential for estimating the dry deposition of mercury and for identifying the source or sources of the mercury deposited to the surface.

2001-Present: In the fall of 2001, a grant was received from the Great Lakes Protection Fund to continue the mercury deposition sample collection and analysis. The AQD, partnering with the U of M, was awarded the funds to develop a mercury monitoring network. The Michigan Mercury Monitoring Network (sites shown in **Figure 6-4**) includes monitoring of total mercury concentrations and deposition on a daily-event basis using automated wet-only collectors designed for trace element collection. In addition to mercury, a suite of other trace elements and major ions are monitored concurrently to allow analysis of the sources and patterns of the mercury wet deposition. Sites were established in three urban areas (Grand Rapids, Flint, and Detroit) because Michigan lacks long-term mercury data from urban areas. This study also continued the long-term event-based mercury deposition recorded at Dexter, Pellston, and Eagle Harbor. The first and second year's annual reports were submitted to the Great Lakes Protection Fund.[155] Data from the studies demonstrated the influence of local sources and the importance of speciated mercury monitoring to assess anthropogenic source contributions to deposition of mercury (Liu et al., 2007). The AQD and U of M received additional funding to extend this project through the spring of 2006 from the EPA's Great Lakes Atmosphere Deposition program.[156] A final report will be completed in 2007.

FIGURE 6-4: MICHIGAN MERCURY MONITORING NETWORK SITES

It was the hope that this project would be able to continue monitoring at some sites established in the first year to allow trend analysis. Unfortunately, funding is no longer available to continue operation of the network and in 2006, Eagle Harbor, Flint, and Detroit stopped operation. However, Pellston and Dexter will continue in 2007 thanks to funds from the Clean Michigan Initiative. In addition, another Great Lakes Atmosphere Deposition grant fund will continue operation of one monitor in west Michigan (either Holland or Grand Rapids) beginning in 2007 for one to two years.

In summary, the network of mercury monitoring sites operational in Michigan throughout the years has been funded by the Michigan Great Lakes Protection Fund, EPA's Great Lakes Atmosphere Deposition program, and the Clean Michigan Initiative. Event precipitation samples have been collected at six Michigan sites (**Figure 6-4**). Speciated ambient mercury measurements were performed simultaneously at the Dexter and Detroit sites using automated Tekran instrumentation. The concentrations of RGM in Detroit are highly variable, but significantly higher than those observed at Dexter. The concentrations of all forms of mercury are higher at Dexter when air mass transport is from the east out of the Detroit corridor. The levels of RGM and Hg(p) are significantly lower at Dexter than those measured in Detroit at the same time. Thus, a fairly significant gradient in the ambient levels of mercury responsible for the dry deposition is suggested. **Table 6-1** summarizes the mercury deposition data in Michigan.

[155] These reports are available on the AQD's website at http://www.michigan.gov/deqair.
[156] Information on the Great Lakes Atmosphere Deposition program is at http://www.glc.org/glad/ .

TABLE 6-1: SUMMARY OF ATMOSPHERIC MERCURY DEPOSITION DATA IN MICHIGAN

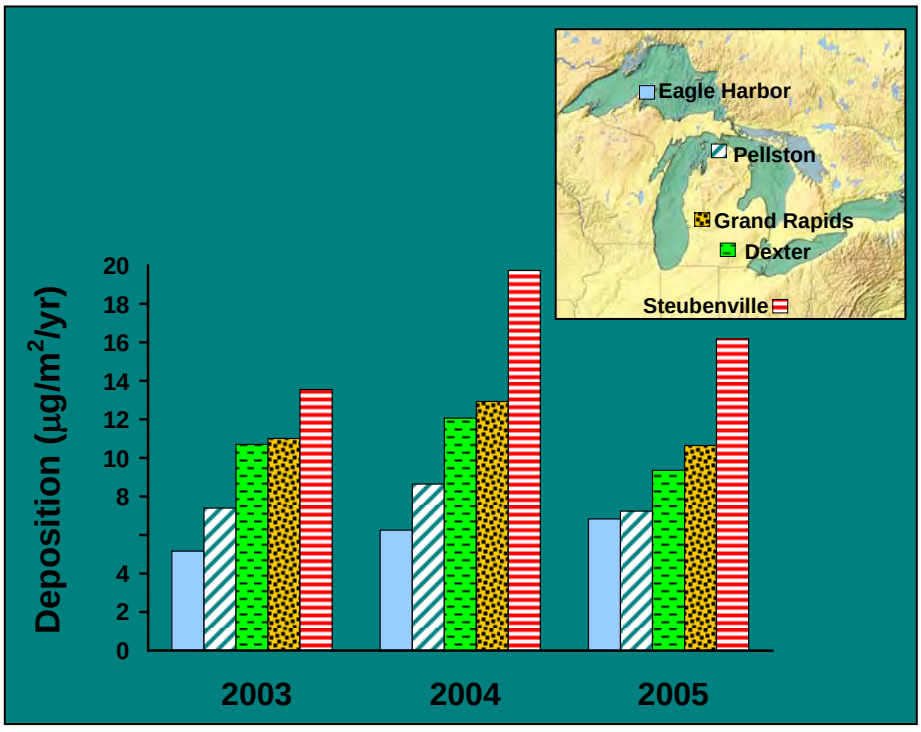
LOCATION	YEARS OR MONTHS	MEASURED AND ESTIMATED MERCURY DEPOSITION (µg/m^2/yr)			REFERENCE
		WET	DRY	TOTAL (WET+DRY)	
Background in Michigan[1]	Current	NA	NA	~8 +/- 4[1]	Keeler, 2007 (personal communication)
Eagle Harbor	1995-2003	5-8 Measured	5-8 Estimated	~10-16	Keeler and Dvonch, 2005
	2003-2005	5-6.5 Measured	5-6.5 Estimated		Dvonch et al., 2006
Pellston	1995	8.0 Measured	8.0 Estimated	~16	Keeler and Dvonch, 2005
	1996	9.4 Measured	9.4 Estimated	~18.8	
	1997	7.4 Measured	7.4 Estimated	~14.8	
	1998	10.7 Measured	10.7 Estimated	~21.4	
	1999	10.4 Measured	10.4 Estimated	~20.8	
	2000	7.4 Measured	7.4 Estimated	~14.8	
	2001	7.6 Measured	7.6 Estimated	~15.2	
	2002	11.9 Measured	11.9 Estimated	~23.8	
	2003	7.4 Measured	7.4 Estimated	~15.0	
	2004	8.6 Measured	8.6 Estimated	~17.2	Keeler, 2007 (personal communication)
	2005	7.4 Measured	7.4 Estimated	~14.8	
	2006	6.7 Measured	6.7 Estimated	~13.4	Dvonch et al., 2006
Dexter	1997-1998	10.4 Measured	10.4 Estimated	~20.8	Keeler, 2001
	1998-1999	11.0 Measured	11.0 Estimated	~22.0	
	1994-2002	9-16 Measured	9-16 Estimated	~18-32	Keeler and Dvonch, 2005
	2003-2005	9-12 Measured	9-12 Estimated	~18-24	Dvonch et al., 2006
South Haven	1997-1998	11.9 Measured	11.9 Estimated	~23.8	Keeler, 2001
Detroit	4/1996-10/1996	14.8 Measured	10.2 Measured	~25.0	Gildemeister, 2001; Gildemeister et al., 2005; Wayne County, 2000
	2003-2006	10-13 Measured	10-13 Estimated	~20-26	U of M
Grand Rapids	2002	10 Measured	10.0 Estimated	~20.0	U of M
	2003-2005	11-13 Measured	11-13 Estimated	~22-26	Dvonch et al., 2006
Flint	2005	8-10 Measured	8-10 Estimated	~16-20	U of M
Lake Michigan	7/1994-10/1995	10.6 Measured	9.7 Estimated	12.5 (without re-emission of 7.8)	Landis and Keeler 2002
Lake Superior	2000			~9.0 Estimated	Rolfhus et al., 2003
North America vs. Great Lakes				14.3-19.8 (N. America) 135 (global background + local emissions)	Pirrone et al., 1998
Seney National Wildlife Refuge, MI NADP-MDN	2004	7.6 µg/m^2/yr (weekly composite precipitation samples collected & analyzed)	7.6 Estimated	~15.0	David Gay, Associate Research Scientist MDN Coordinator, Illinois State Water Survey, University of Illinois; info available at http://nadp.sws.uiuc.edu/mdn/.
	2005	6.5 µg/m^2/yr (weekly composite precipitation samples collected & analyzed	6.5 Estimated	~13.0	
Sterling Heights, MI NADP-MDN	2006	10.0 µg/m^2/yr (weekly composite precipitation samples collected & analyzed)	10.0 Estimated	~20.0	
Leelanau County, MI NADP-MDN	Data not available-Site started on 5/8/07				

[1] The term "background," as applied here, refers to the estimated current level that is not attributable to any known current anthropogenic release.

DEPOSITION MONITORING STUDY NEAR MICHIGAN

While much progress has been made in identifying and quantifying mercury emission sources, few field-based studies have been attempted in Michigan to identify the mechanisms and processes critical to enabling predictive modeling of mercury transport, transformation, and deposition. These include the characterization of speciated mercury emissions, ambient air, and ultimately deposition. However, an enhanced mercury monitoring study was conducted recently near Michigan in Stubenville, Ohio by the U of M Air Quality Laboratory and EPA. The comprehensive monitoring and modeling study in the Ohio River Valley collected event-based wet deposition data for 2003-2004. This data was coupled with source apportionment modeling and two new EPA Multivariate statistical models known as PMF (positive matrix factorization) and UNMIX. The data demonstrated that the dominant contributor to the mercury wet deposition in Ohio was from coal-fired EGUs (~70%). Meteorological data also indicated that a majority of the mercury deposition was due to local and regional sources (Keeler et al., 2006). A comparison of the Michigan wet deposition data to the Ohio data, as shown in **Figure 6-5**, demonstrates that Michigan's wet deposition data is not as elevated as the levels found in Ohio.

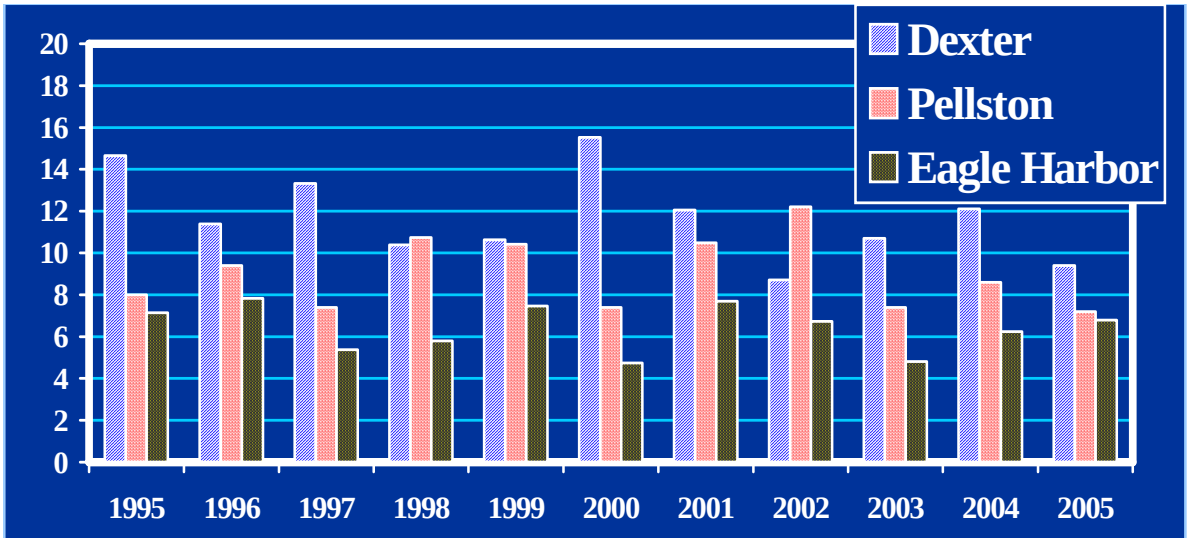
FIGURE 6-5: COMPARISON OF MICHIGAN AND OHIO MERCURY WET DEPOSITION DATA FROM 2003 TO 2005



MICHIGAN ATMOSPHERIC MERCURY DEPOSITION TREND DATA

Recognizing that long-term precipitation records are essential for establishing trends and understanding the impacts of changes in mercury emissions, the U of M Air Quality Laboratory collected a decade of event precipitation data samples at three sites in Michigan (Dexter, Pellston, and Eagle Harbor, previously shown in **Figure 6-2**). **Figure 6-6** displays the annual mercury wet deposition measured in event precipitation samples at these sites for the period 1995 to 2005.

FIGURE 6-6: ANNUAL MERCURY DEPOSITION TOTALS FROM EVENT PRECIPITATION SAMPLES COLLECTED AT THREE MICHIGAN SITES FROM 1995 TO 2005



Over the 10-year deposition record, a clear decreasing gradient from south to north was observed. While the year-to-year variability in the deposition was on average 18% at each site, the 10-year total wet deposition sum at Dexter was 1.6 times the deposition collected at Pellston and 2.1 times that measured at the Eagle Harbor site. With the exception of the 2002 mercury deposition for Pellston (the maximum annual deposition over the 10-year record) the south to north decreasing gradient in deposition was observed each year. Furthermore, there was not an obvious trend in the deposition rates at the three sites over the decade of measurements. While there have been recent attempts to control mercury emissions within the region and nationally over the past decade, this data illustrates the consistent long-term impact that anthropogenic sources in the southern part of the Great Lakes region have had on mercury deposition across the Great Lakes Basin (Keeler and Dvonch, 2005). Year-to-year variability in the precipitation amount received at a site together with meteorological transport differences from year to year largely control the deposition from site to site over time.

Results from monitoring wet deposition and fish concentrations are considered the primary indicators for detecting mercury changes in the environment (Mason et al., 2005a). Therefore, support should continue for mercury wet deposition monitoring and fish tissue concentrations to further detect any trends in Michigan.

COMPREHENSIVE AMBIENT AND ATMOSPHERIC DEPOSITION NETWORK STRATEGY

While several PBT air monitoring and atmospheric deposition studies have been conducted in the past several years, they were for a limited time frame and for a limited set of pollutants. These somewhat fragmented studies demonstrate the need for implementation of a comprehensive, continuous atmospheric deposition network within the state and region. In 2002, the AQD finalized a comprehensive ambient and atmospheric deposition network strategy, *The Development of an Air Toxics Monitoring Strategy for Michigan* that outlines AQD's long-term goals for air toxics monitoring, including PBTs.[157] Implementation depends on securing an adequate funding source.

[157] The strategy is available at http://www.deq.state.mi.us/documents/deq-aqd-toxics-peerRVstrategy.pdf and includes information on the MDN.

GREAT LAKES STATE MERCURY DEPOSITION MONITORING DISCUSSION GROUP

MDEQ staff also participated with the Great Lakes Commission and other Great Lakes States in compiling the "*Mercury Deposition Monitoring in the Great Lakes States*" report.[158] This report highlights the importance of conducting mercury deposition monitoring and includes 13 recommendations for further work in the region.

OTHER STATE ATMOSPHERIC TRENDS

In Florida, local air emission sources of mercury in south Florida were at peak levels in 1991. Between 1991 and 2000, the local mercury air emissions were reduced from 3,100 lbs/yr to 115 lb/yr (a 92% reduction). Regional and global sources were also estimated. Several lines of evidence support the contention that local mercury emission sources constituted at least 50% (and possibly as high as 71%) of mercury wet deposition in south Florida in the mid-1990s. Wet deposition was measured in Everglades National Park from late 1993 to 2002. The volume-weighted mean mercury concentration in wet deposition decreased over this period from about 13 to 10 ng/L. This agrees reasonably well with the reduction in local emissions over that time period (substantial 1990-1993 emission reductions occurred before the deposition monitoring began). Total deposition measurements in 1995-1996 indicate a deposition rate of 35.3 $\mu g/m^2/yr$. Dated sediment core studies found that the atmospheric deposition of mercury was at a rate of 53 $\mu g/m^2/yr$ in 1990, and 21 $\mu g/m^2/yr$ in 2001. These data suggest a decline of about 60% overall. The everglades largemouth bass and great egret (feather) mercury levels declined about 75% from the mid-1990s to the year 2002. (Atkeson et al., 2003; Atkeson et al., 2005).

SUMMARY

The importance that the urban/industrial areas have in regards to the contribution that they make to overall loadings of mercury and subsequent deposition has been well documented (Keeler and Dvonch, 2005; Keeler et al., 2006; Lindberg et al., 2007). It has also been well documented that if deposition of mercury is reduced then a reduction in the environment will also be evident (Lindberg et al., 2007; Atkinson, et al., 2005; Engstrom, et al., 1997; Bindler, et al., 2001). If this report's recommendations are fully implemented, the concentration in Michigan's environment should decrease over time.

6.1.3 MODELING ATMOSPHERIC MERCURY DEPOSITION

Atmospheric transport and deposition models are also used to estimate the contributions of mercury emissions from various sources to local and regional deposition. These models rely on good emission inventory data, adequate understanding of atmospheric transformations of mercury, and ambient monitoring data or comprehensive measurement studies against which to compare model predictions (see discussion in Seigneur et al., 2004). Recent efforts to model mercury transport and deposition in North America (including in the Great Lakes region) have included approaches using Eulerian models (e.g., Seigneur et al., 2003); Lagrangian models (e.g., EPA, 1997e; Cohen et al., 2004); and a hybrid deposition approach (Landis and Keeler, 2002). However, there are many uncertainties associated with atmospheric mercury transport and fate modeling including:

- There is a lack of speciated stack test data for most mercury sources in the state, as well as other point and area sources within and outside of the state. Therefore, a number of uncertainties in mercury emissions remain.[159]

[158] This report is available at http://www.glc.org/glad/pdf/MercuryReport_May07.pdf.
[159] See for example Murray and Holmes, 2004.

- Regional 3-D Eulerian models are not designed to simulate localized impacts of point sources at the grid cell level. The modeled impact within a grid cell containing a source may overestimate the average impact within that grid cell (e.g. 20 per square centimeters), but could underestimate a more localized "hot spot." In addition, even regional predictions are sometimes not internally consistent. For example, in Seigneur et al., (2004), strong plumes of atmospheric Hg(0) are evident in downwind regions of major source areas in Europe and East Asia, but not for U.S. sources.
- Challenges exist in integrating meteorological processes with physio-chemical processes in models (e.g., off-line approaches, where meteorological data is fed in periodically versus on-line approaches, where the two are integrated) (Dastoor and Larocque, 2004).
- The potential for strong influence of assumed boundary conditions exists because of the large volume of air mass transported over continents. Assumed boundary conditions that are too high or low by even relatively small amounts can significantly alter the outcome of models. For example, a crude calculation shows that assuming a baseline concentration of 1.6 ng/m^3 in the lowest 10 km of the atmosphere over the continental U.S. leads to a baseline mercury mass over the country at any one time that is about 8.5 metric tons higher than is the case assuming a concentration of 1.5 ng/m^3. While this issue may be more relevant to modeling efforts where boundary conditions are assumed rather than calculated as intermediate output (as in the Seigneur et al., 2004 approach), in either case accurate input concentration data for regional models are important.
- The inability to show ambient and the wet plus dry deposition fields on a shorter time frame (i.e., daily) to validate speciated concentrations. Some global/regional mercury modeling has included comparisons of atmospheric concentrations on shorter time frames to measured data (see for example Dastoor and Larocque, 2004).
- The limited amount of field-based data on the mechanisms and processes critical to enable predictive modeling of mercury transport, transformation, and deposition. For example, there have been very few attempts at direct estimates of mercury dry deposition, and values for surrogates (such as nitric acid) vary by nearly two orders of magnitude (see Seigneur et al., 2004).
- The lack of Michigan specific speciated data for validating the dry deposition component of the model.

In general, most models do not adequately account for the reactions leading to the local and regional formation of RGM. All models do suggest, however, that emissions within the U.S. are important sources for regions of high mercury deposition. Given the rapid deposition of RGM, and the potential for mercury to be oxidized in the atmosphere, emissions of mercury can contribute to local and regional deposition. Thus, mercury emissions are a global, regional, and local problem.

The cycling of mercury through the atmospheric-terrestrial-aquatic compartments is complex, with many nonlinear processes that link atmospheric mercury emissions and MeHg bioaccumulation in fish and wildlife. Although a significant effort has been made over the past decade to understand the causal link between mercury emissions to the atmosphere and MeHg bioaccumulation into the aquatic food chains, currently no coherent assessment can quantitatively document the temporal environmental changes in mercury levels across ecosystems. The process of linking atmospheric mercury deposition to MeHg concentrations in fish is complicated by many uncertainties, such as the source of mercury deposition at any specific location and the sensitivity of different

watersheds and waterbodies to mercury inputs, specifically in terms of its rate of conversion to MeHg. Other factors, such as changes in the availability of sulfate and organic matter can impact bacterial activity and may cause an increase in fish MeHg concentrations even as atmospheric mercury deposition decreases. However, use of isotopic tracers show promise for providing this link (Hintelmann, et al., 2002).

6.1.4 MERCURY MONITORING WORKSHOPS

As part of the EPA-funded Tri-State Mercury Monitoring Grant, the AQD co-sponsored the Mercury Monitoring Workshop with EPA titled, Great Lakes Regional Workshop Proceedings - Measuring Atmospheric Mercury: Goals, Methods and Results in East Lansing, Michigan, on March 26 to 27, 2003.[160]

A Michigan Mercury Research Workshop was held June 15, 2006 in Romulus. The workshop was funded by the WB and focused on multi-media monitoring in Michigan. Mercury scientists with expertise in atmosphere, water, sediments, mining and wildlife were invited to give presentations at the workshop. A discussion followed aimed at assisting MDEQ with its decisions on mercury monitoring priorities.[161]

6.1.5 STACK MERCURY MONITORING

There are currently several facilities in Michigan that have been requested to conduct stack tests for mercury. There are three main methods for mercury stack testing which are Method 29, ASTM D6784-02, and the Ontario-Hydro Method (2003). All of these methods are based on Method 5 which is a method for particulate monitoring and includes a heated filter and an impinger train. Method 29 does not speciate mercury, but does allow for the collection of other metals (including arsenic, lead, cadmium, chromium, manganese, etc.). The ASTM and Ontario-Hydro methods both speciate mercury [separates Hg(0), RGM and Hg(p) forms]. The Ontario-Hydro Method is most complex in that the impingers are recovered separately, which allows the analysis of breakthrough and also requires a spike train along with reagent blanks for quality control. This makes the method more resource intensive (see **Appendix T** for a comparison of the sampling methods).

Mercury continuous emission monitors provide continuous data, whereas stack testing provides a "snap-shot" of the emissions when sampled. Continuous emission monitors are required for coal-fired EGUs by 2009 under the CAMR. Currently there are at least seven mercury continuous emission monitors on the market or in development according to AQD's Technical Programs Unit staff. There are currently several issues that are still being tested that mostly involve the issue of mercury transport in the sampling lines. Mercury mass balance reporting has yet to be required or reviewed for sources in Michigan. At a minimum, the coal-fired EGU sector will be required to follow the CAMR stack test protocol. Other atmospheric sources of mercury will continue to be required to conduct stack testing as well, to help assess local impacts. To determine local impacts, it is critical to conduct speciation stack testing because deposition is dependent on the form of the mercury emitted (see **Chapter 6.1.2** for discussion on speciation).

[160] The AQD workshop proceedings and power point presentation are available at http://www.deq.state.mi.us/documents/deq-aqd-toxics-HgWorkshop.doc.
[161] The WB workshop is at http://www.deq.state.mi.us/documents/deq-wb-swas-mercury-workshoprpt.pdf.

6.2 WATER BUREAU (WB)

6.2.1 SURFACE WATER

The MDEQ and the MDNR have collected data from surface water monitoring sites located throughout Michigan. Michigan's historical mercury surface water data collected is available from the Michigan Surface Water Information Management (MiSWIM) System and can also be obtained from the EPA's two national water quality data management systems, the Legacy Data Center (LDC) and the Storage and Retrieval (STORET).

The MiSWIM application is an interactive map-based system that allows users to view information about Michigan's surface water. It was developed through a cooperative effort by the MDEQ, MDNR, and the Michigan Department of Information Technology. Users are able to view and download data collected by the MDEQ and the MDNR.[162]

The EPA's LDC and STORET data management systems contain water quality information for the nation's waters. The LDC is a static, archived database and STORET is an operational system actively being populated with water quality data.[163]

MICHIGAN WATER CHEMISTRY MONITORING PROJECT (WCMP)

The MDEQ initiated its WCMP in June 1998. The goals of the WCMP are to assess the current status and condition of individual waterbodies of the state and determine whether standards are being met; measure temporal and spatial trends in the quality of Michigan's surface waters; provide data to support the MDEQ water quality programs and evaluate their effectiveness; and detect new and emerging water quality problems.

The current study design of the WCMP calls for annual contaminant monitoring at approximately 49 locations statewide, including streams tributary to the Great Lakes, the Great Lakes connecting waters, Saginaw Bay, and Grand Traverse Bay. Depending upon the monitoring station, as few as four or as many as 12 mercury samples are collected in a given year.

Mercury samples are collected and handled using the ultra-clean techniques outlined in EPA Method 1669, "*Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels*." Samples are analyzed for total mercury using EPA Method 1631, which has a method detection limit of 0.2 ng/L. Exceedance is determined by comparison with Michigan's WQS of 1.3 ng/L total mercury. All total mercury results currently available from the WCMP (June 1998 through November 2002) are summarized in **Table 6-2** (Aiello, 2004).

TABLE 6-2: MERCURY CONCENTRATIONS IN SURFACE WATER FROM 1998 TO 2002 (NG/L)

LOCATION	MEAN	MEDIAN	RANGE	# OF EXCEEDANCES/N	% OF EXCEEDANCES
Waters Tributary to Lake Michigan	3.74	2.40	ND – 55	276 / 378	73%
Waters Tributary to Lake Huron	1.61	0.71	ND – 14	114 / 300	38%
Waters Tributary to Lake Erie	4.14	2.30	ND - 107	204 / 303	67%
Waters Tributary to Lake Superior	3.85	3.00	0.3 - 10	28 / 35	80%

N = Number of samples; ND = Non detect

As shown in **Table 6-2**, the majority of samples collected statewide for total mercury between 1998 and 2002 exceeded the Michigan WQS of 1.3 ng/L. Temporal trend analyses are not yet possible in this early stage of the project.

[162] MiSWIM can be accessed at www.michigan.gov/miswims.
[163] Both of the EPA's LDC and STORET data can be found at www.epa.gov/storet/dbtop.html.

SURFACE WATER MONITORING FOR MERCURY IN MICHIGAN'S LAKES AND RIVERS

Tributaries to Great Lakes: A total of 67 monitoring stations have collected ambient surface water samples for low level mercury as part of the Michigan WCMP. These 67 stations represent ambient water quality in 31 Great Lakes tributary watersheds, the Great Lakes connecting channels, Saginaw Bay and Grand Traverse Bay. The Great Lakes tributary monitoring stations were grouped according to the following five areas for the purpose of looking at spatial patterns in mercury levels in different geographical regions of Michigan: U.P., and the northeastern, northwestern, southeastern, and southwestern L.P.. A single data group was chosen to represent the entire U.P. after preliminary analyses of the U.P. data showed that median mercury concentrations for the western U.P. and eastern U.P. subgroups were identical.

The results show the median total mercury concentrations in the Great Lakes tributaries from the northeastern and northwestern L.P. (0.48 ng/L and 1.25 ng/L, respectively) were significantly lower than those of the other regions. The median U.P. total mercury concentration (2.44 ng/L) did not differ significantly from those in the southeastern and southwestern L.P. (2.35 ng/L and 3.02 ng/L, respectively).

Inland Lakes and Streams: Additional surface water total mercury samples have been taken from 84 rivers/streams and 176 lakes/impoundments throughout Michigan in 2001 and 2002. In terms of Michigan geography, mercury appears to be slightly higher in the L.P. rivers than the U.P. rivers. The geographical pattern for total mercury in lakes/impoundments was opposite that for rivers, with total mercury concentrations generally higher in the U.P. (Great Lakes Environmental Center, 2002).

The 2002 data for rivers and lakes is included in **Figures 6-7** and **6-8** and demonstrates that Michigan lakes typically exceed the WQS of 1.3 ng/L while rivers do not.

FIGURE 6-7: MEAN TOTAL MERCURY CONCENTRATIONS IN MICHIGAN LAKES FOR 2002

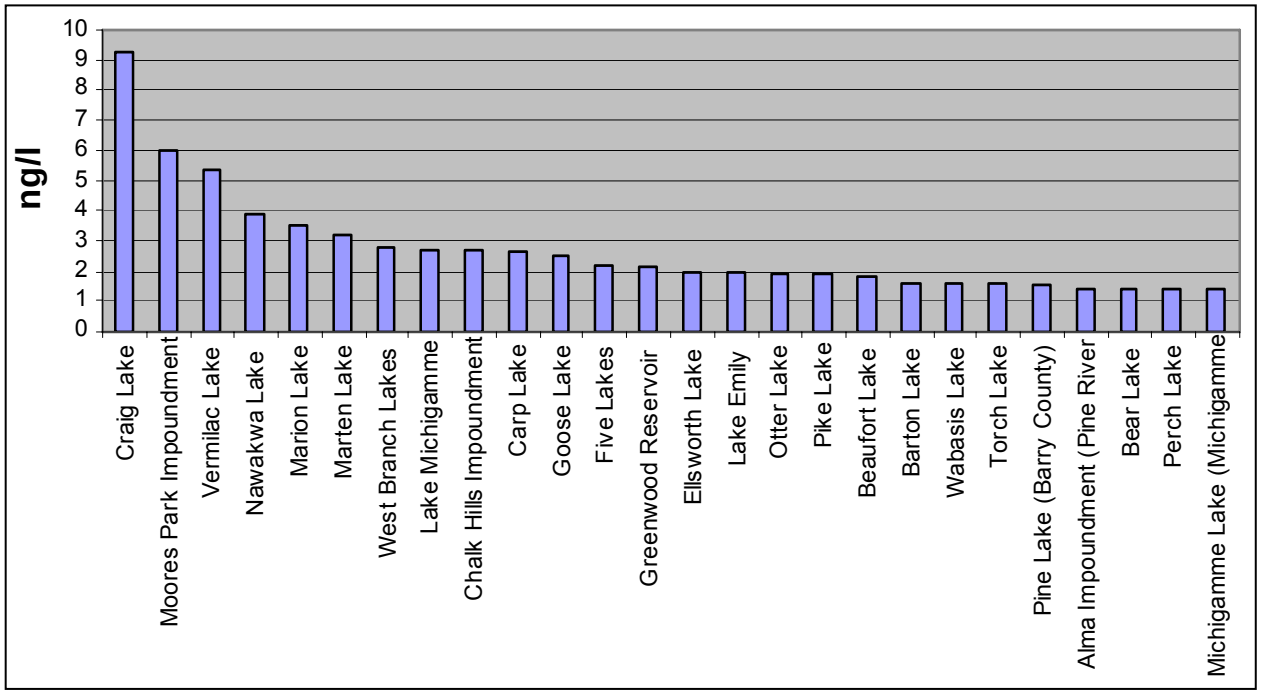
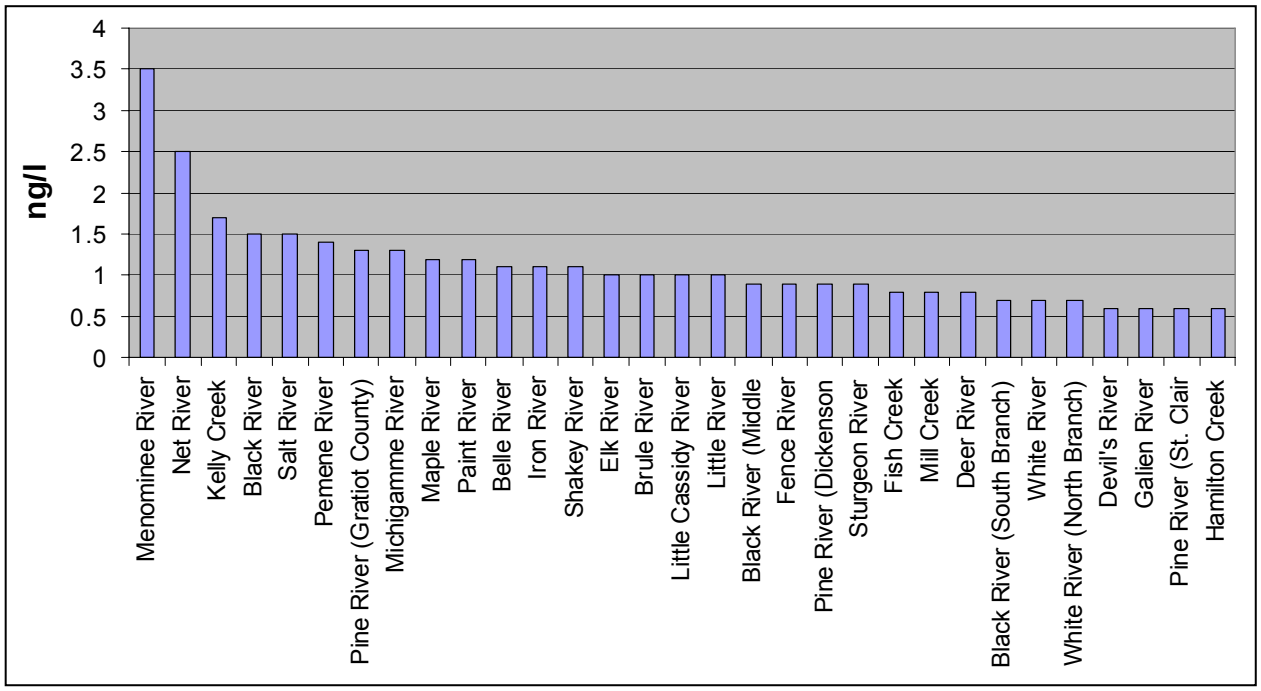


FIGURE 6-8: MEAN TOTAL MERCURY CONCENTRATIONS IN MICHIGAN RIVERS FOR 2002



Point Source Discharges of Mercury: Data obtained from compliance monitoring for point source discharges indicate that 42 out of 45 facilities with mercury limits or monitoring requirements have an arithmetic mean mercury concentration below 10 ng/L with 35 facilities less than 5 ng/L (see **Chapter 3.2.1** for further discussion).

6.2.2 GROUNDWATER

As previously stated in **Chapter 3.2.2**, the Groundwater Program regulates the discharge of wastewater to groundwater under Part 31, Water Resources Protection, of the NREPA. The Groundwater Program does not have a monitoring requirement for mercury in any permitted discharge to groundwater due to the lack of reasonable potential for the presence of mercury within the discharge stream.

6.2.3 DRINKING WATER

As previously stated in **Chapter 3.2.3**, the MDEQ has primary enforcement authority in Michigan for the Federal Safe Drinking Water Act under the legislative authority of the Michigan Safe Drinking Water Act. Local municipalities are responsible for monitoring their respective community drinking water supplies to ensure public health. The MDEQ contracts with local health departments to maintain a noncommunity program in each county. There are no known problems associated with mercury contamination of drinking water sources within the state of Michigan.

6.2.4 SEDIMENTS

MICHIGAN INLAND LAKE SEDIMENT TREND MONITORING PROJECT

Many toxic chemicals entering lakes become adsorbed to particles such as organic matter, clays, or iron oxides. The ultimate fate of these particle-bound chemicals is to become deposited on the lake bottom. As this deposition happens over time, sediments in lakes become a chemical "tape-recorder" of the temporal trend of toxic chemicals in the environment. Contaminated sediments can directly impact bottom-dwelling organisms, and represent a continuing source of toxic substances in aquatic

environments that may impact wildlife and humans through food or water consumption. Thus, the chemistry of lake sediments is an integral part of Michigan's overall environmental quality monitoring efforts.

In 1999, the MDEQ established an Inland Lake Sediment Trend Monitoring Project in partnership with MSU. This project was designed to provide data to evaluate the effectiveness of air and water quality legislation and the NPDES permitting program in reducing contaminant levels in the sediments of the waters of the state.

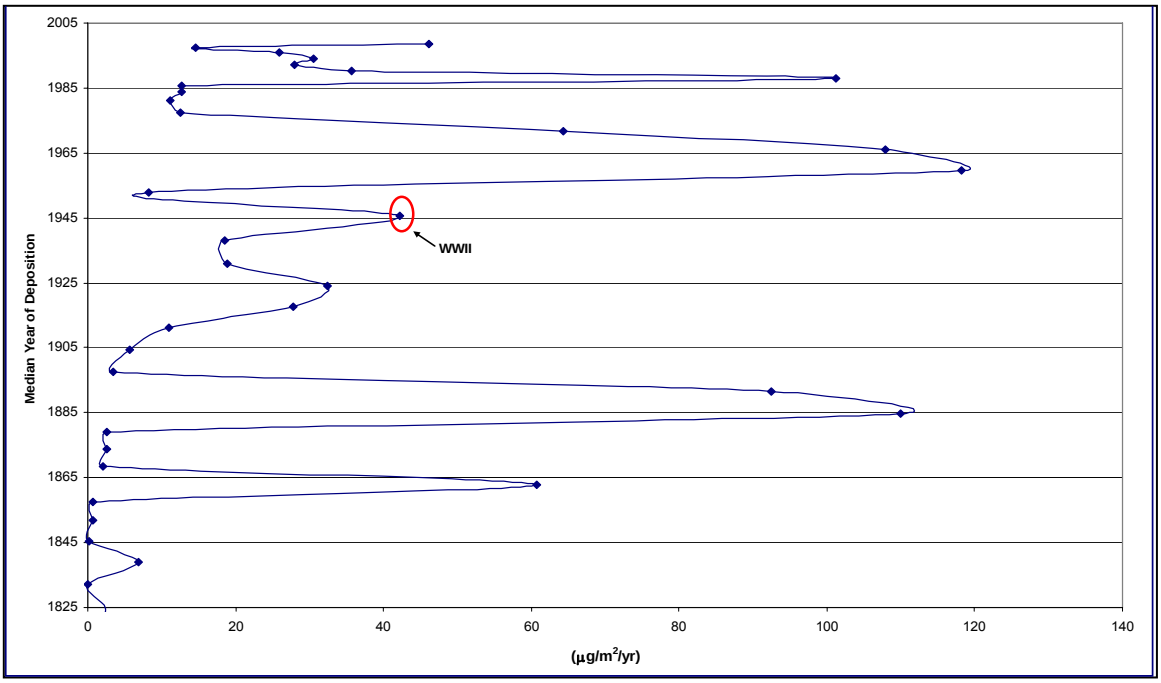
From the summer of 1999 to 2004, sediment cores were collected from 27 inland lakes in Michigan (Parsons et al., 2006). **Table 6-3** lists the inland lakes sampled and year sampled. Lakes were chosen to reflect the diversity of land uses in the state. Selection was also based on position along north-south and east-west transects and proximity to state borders. This latter criterion was an important factor in addressing the likelihood of long-range atmospheric transport of contaminants to the state.

TABLE 6-3: LAKES SAMPLED SINCE 1999 FOR THE MICHIGAN INLAND LAKES SEDIMENT TREND MONITORING PROJECT

1999	2000	2001	2002	2003	2004
Cass Lake	Crystal Lake (Montcalm Co.)	Crystal Lake (Benzie Co.)	Houghton Lake	Muskegon Lake	Lake George
Elk Lake	Littlefield Lake	Mullett Lake	Imp Lake	Birch Lake	Otter Lake
Gratiot Lake		Lake Cadillac	N. Manistique Lake	Sand Lake	Crystal Lake (Mecosta Co.)
Higgins Lake		Paw Paw Lake	Torch Lake	Avalon Lake	Hacker Lack
Gull Lake		Whitmore Lake	Witch Lake	Stupac Lake	Round Lake (Dickinson Co.)

Initial results indicate that the method used to analyze for mercury in the sediment needs to be refined. This resulted in a delay in the reporting of the data and the development of a refined and improved analytical method. Preliminary results from this monitoring effort show that spatial trends of decadal-interval inland lake sediment mercury accumulation rates do not clearly indicate a regional or global source signal. Common among many lakes are episodic mercury accumulation events, which occur over short time periods (years) with regularity. As shown in the following **Figure 6-9**, some of the events can be attributed to historical increases in U.S. mercury consumption (e.g., World War II); while others are a possible indication of watershed-scale sources of mercury releases. Many lakes also exhibit spikes with an undefined source of mercury to the lake. This is just a sample of the currently available data.

FIGURE 6-9: MERCURY ACCUMULATION PRELIMINARY RESULTS FOR HIGGINS LAKE



The preliminary results show background (i.e., pre-industrial revolution) mercury concentrations ranging from 0.015 to 0.1 mg/kg (similar to background levels found in the Great Lakes), and peak mercury concentrations ranging from 0.16 to 1.1 mg/kg (Marvin et al., 2004). For comparison purposes, sediments with mercury concentrations at or exceeding 2 mg/kg are considered to have a very high probability of causing severe effects on bottom-dwelling organisms. Sediment clean-up efforts often have a goal of 1.0 mg/kg of mercury in the sediment.

INLAND LAKE SEDIMENT CORE STUDY

A study of sediment cores collected 1986 to 1990 from 66 inland lakes in Michigan indicated an average historical background concentration of 0.05 mg/kg (Evans et al., 1991). This study supports the background levels suggested by preliminary results from the Inland Lake Sediment Trend Monitoring Project described in **Chapter 6.2.4**. Surficial sediment levels in lakes without known point source discharges ranged from 0.05 to 0.157 mg/kg, and surficial sediment levels in lakes with known point source discharges ranged from 0.055 to 8.3 mg/kg (Evans et al., 1991). This study concluded that increased atmospheric deposition was likely the cause of observed elevated levels except for Deer Lake, where a direct point source discharge was clearly the cause. Deer Lake was the only site in this study that had sediment cores whose concentrations exceeded 2 mg/kg (MDNR, 1992).

From the summer of 1999 to 2004, sediment cores were collected from 27 inland lakes in Michigan. Background mercury concentrations range from 0.005 to 0.10 ppm. Background rates of mercury accumulation and concentrations are highest in the sediments from U.P. lakes and lowest in the northern L.P. lakes.

Spatial patterns for anthropogenic mercury accumulation rates in Michigan lake sediments suggest that four areas (southeast, western shore, U.P., and Roscommon area) exhibit similar rates over the last four decades. This suggests the influence of a sub-regional source or related processes occurring in these watersheds. In general, the anthropogenic mercury accumulation rates in sediments are higher in lakes near

industrial and population centers than those in more rural settings, e.g., U.P. lakes. The variability in anthropogenic mercury inventories among lakes suggest local sources play a significant role in mercury accumulation in Michigan's inland lakes.

6.2.5 WILDLIFE MONITORING

MICHIGAN WILDLIFE CONTAMINANT MONITORING PROJECT

The bald eagle (*Haliaeetus leucocphalus*) is considered an ideal bio-sentinel species because it is a top-level predator that feeds primarily on fish and waterbirds, it often returns to the same nesting territory year after year, and its large size allows sufficiently large samples to be collected for contaminant analysis.

In the early 1900s, there was an increase in the concentrations of mercury in adult feathers of bald eagles. In 1999, the MDEQ initiated monitoring of mercury and other contaminants in bald eagles within the Great Lakes region.

To assess both temporal and spatial trends within the Great Lakes region, the first two years of sampling from 1999 to 2000 (Roe, 2001) were compared to the concentrations of mercury in bald eagle nestling feathers measured during 1985 to 1989 (Bowerman et al., 1994). **Table 6-4** shows the geographic mean mercury concentrations in breast feathers of nestling bald eagles from four sub-populations in Michigan and one sub-population in Minnesota (Voyageurs National Park) for the time periods 1985 to 1989 and 1999 to 2000.

TABLE 6-4: MERCURY CONCENTRATIONS IN NESTLING BALD EAGLE BREAST FEATHERS (mg/kg)

LOCATION	1985 to 1989		1999 to 2000	
	n	Mean	n	Mean
Interior L.P., MI	28	8.8	62	8.13
Interior U.P., MI	44	8.1	55	8.40
Lake Superior	19	8.7	33	8.17
Lake Michigan and Huron	10	8.0	57	6.82
Voyageurs National Park, MN	8	20	19	8.84

n = Number of Samples.

For temporal trends, mercury concentrations measured in bald eagle nestlings in 1999 to 2000 were compared with concentrations measured in 1985 to 1989. No significant differences were found between the mercury concentrations in bald eagle nestlings from Michigan between these two time periods. However, a significant decrease was found in the concentrations of mercury in nestlings from Voyageurs National Park, Minnesota, from 1985 to 1989 to 1999 to 2000.

For spatial trends, comparisons were made among mercury concentrations measured in sub-populations of bald eagle nestlings during the same time period. The mercury concentrations measured in 1985 to 1989 in bald eagle nestlings from the Voyageurs National Park were significantly higher than mercury concentrations measured in nestlings from all of the Michigan sub-populations during this same time period. No significant differences were found among mercury concentrations in bald eagle sub-populations measured in 1999 to 2000.[164]

[164] For additional information, see Bowerman et al., 1994; and Roe, 2001.

In summary, mercury was detected in all nestling breast feathers collected during the two time periods. The mean concentrations of mercury in nestling breast feathers for five bald eagle sub-populations within the Great Lakes region ranged from 8.0 to 20 mg/kg (1985 to 1989) and 6.82 to 8.84 mg/kg (1999 to 2000). No relationship was found between the concentrations of mercury in nestling breast feathers and productivity or nest success for either time period. This finding suggests that mercury is not affecting bald eagle reproduction in the Great Lakes region.

MICHIGAN FISH CONTAMINANT MONITORING PROGRAM

The MDEQ monitors mercury in fish fillets to assess the need for sport fishing consumption advisories[165] or commercial fishing regulations, and in whole fish to assess temporal changes and ecological risk. Changes in fish tissue levels can be used to measure the impact of mercury control programs over time.

The MDEQ has analyzed mercury concentrations in about 17,000 edible portion fish tissue samples collected from approximately 550 locations since 1980. The MDCH uses these edible portion data to issue sport fishing consumption advisories in the MDNR's *Michigan Fishing Guide*.[166] As discussed in **Chapter 1.3**, in 1988 the MDCH issued a statewide general mercury advisory regarding the consumption of the following top-predator fish species harvested from all inland lakes (i.e., lakes other than the Great Lakes, and does not include rivers):

- Rock bass, perch, or crappie over 9 inches in length
- Any size largemouth/smallmouth bass, walleye, northern pike, or muskellunge

The advisory was issued when a consistent pattern was seen after analyzing samples from approximately 100 lakes. Sampling has continued, and with a few exceptions, the pattern has remained consistent. Specific lakes or impoundments are listed in the advisory only if the advice for that lake is less restrictive or more restrictive than the general advisory (see details in **Chapter 1.3**).

Currently, the MDEQ collects approximately 600 edible portion samples from about 40 locations per year. Inland lakes with fish having high mercury concentrations tend to be more frequent in Michigan's U.P. when compared to the L.P. lakes. However, differences between regions appear to be slight. Differences between lakes in close proximity can be relatively large and significant.

In 2007, a consortium of the eight Great Lakes States will be releasing an addendum to the Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory entitled "*A Protocol for Mercury-based Fish Consumption Advice*." The document is a science-based assessment of which mercury fish tissue concentrations should be used to issue mercury fish consumption advisories. The document bases its recommendations on the most recent toxicological studies as well as the National Academy of Sciences and the EPA's MeHg assessments.

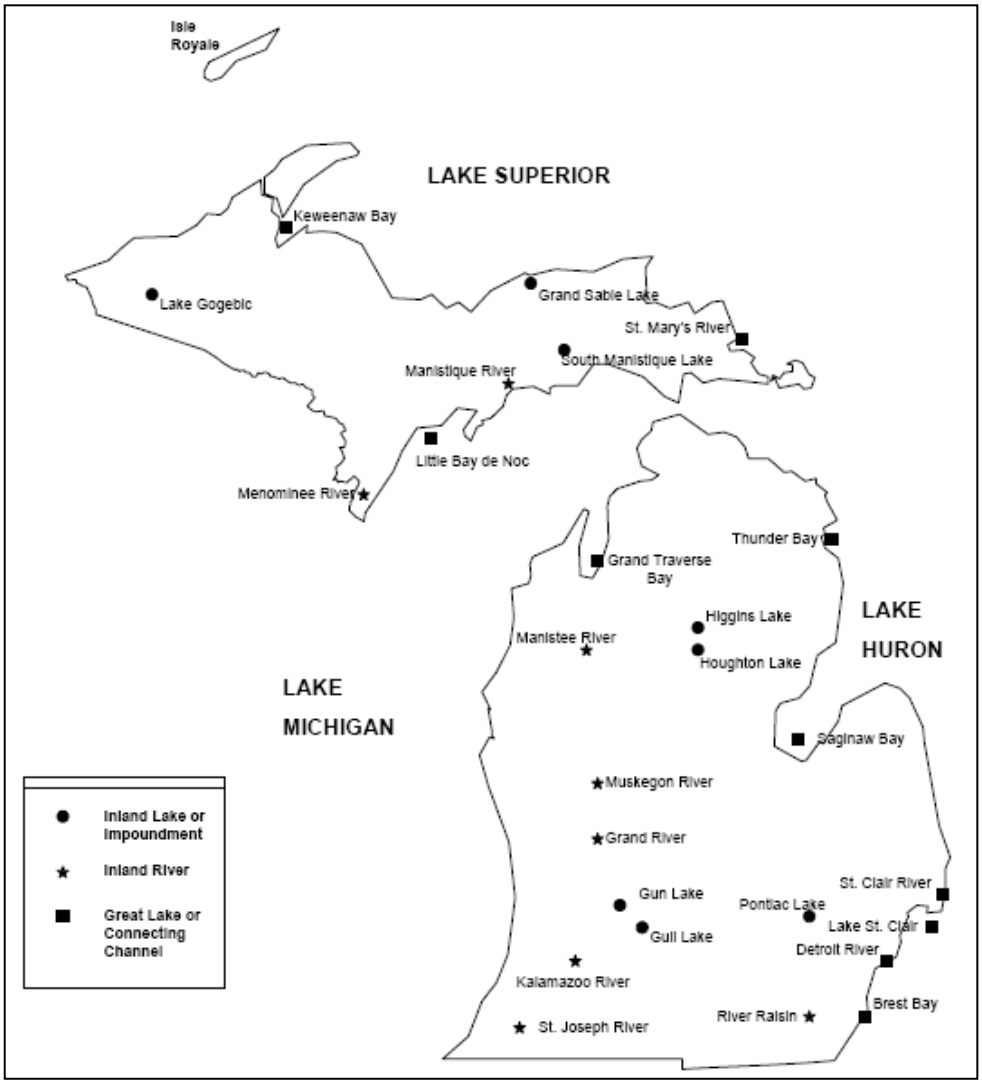
[165] The MDCH's current 2004 Michigan Family Fish Consumption Guide is available at http://www.michigan.gov/documents/FishAdvisory03_67354_7.pdf.

[166] The 2006-2008 Michigan Fishing Guide is available at http://www.michigan.gov/documents/Fishing-Guide_151601_7.pdf.

WHOLE-FISH CONTAMINANT TREND MONITORING PROGRAM

In addition to the edible portion monitoring (discussed above), the MDEQ has conducted a fixed station, whole-fish contaminant trend monitoring program since 1990. Sampling at the program sites (shown in **Figure 6-10**) is conducted every two to four years. Where trends have been detected, mercury concentrations tend to increase in fish from the Great Lakes or connecting channel stations and decrease in fish from inland lakes and rivers. Multiple species were collected at most of the nine fixed stations in the Great Lakes or connecting channels. At five of the stations, mercury concentrations had a median increase of 3.3% per year for several different species (walleye at two sites, lake trout at two sites, and carp at a fifth site), at one location mercury concentrations decreased in carp (decrease of 6.2% per year), and the remaining data sets were unchanged (although the data may be too variable to detect an existing trend).[167]

FIGURE 6-10: WHOLE-FISH CONTAMINANT TREND MONITORING SITES

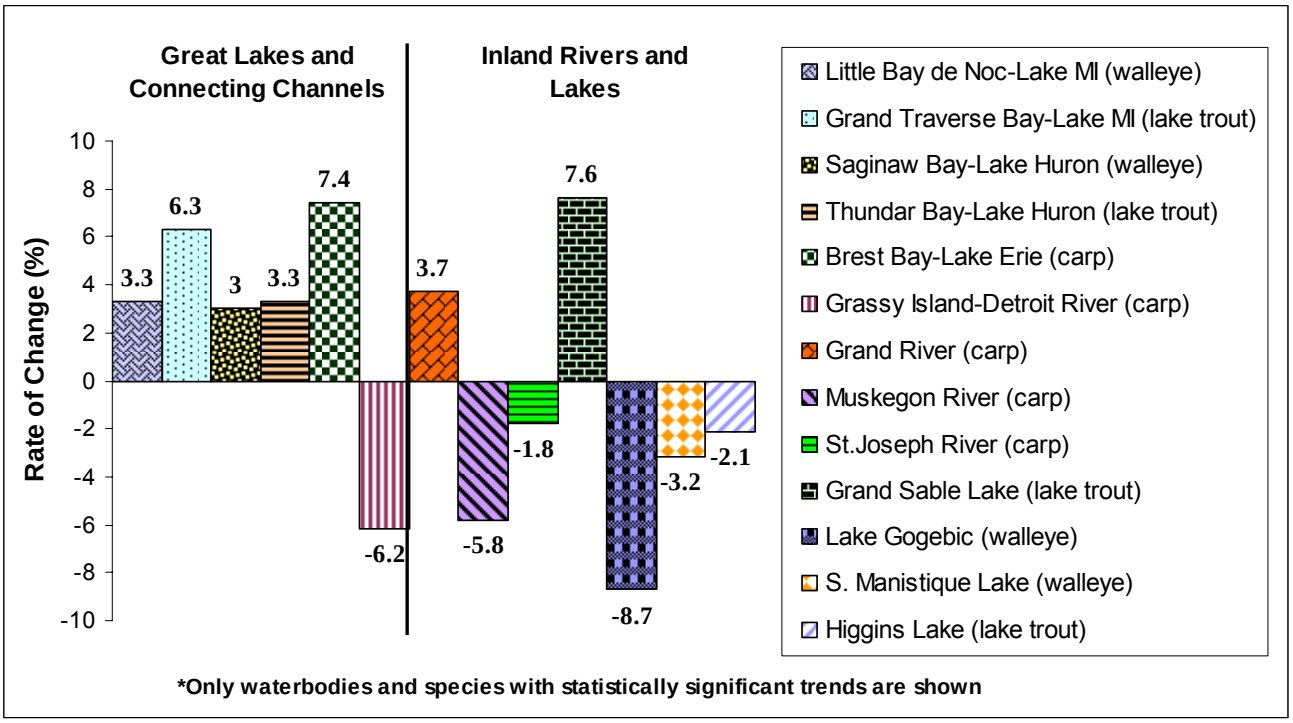


In cases where a significant trend was not detected, minimum detectable trends were calculated. The minimum detectable trend is the smallest possible trend that could

[167] The monitoring trend data is from the Michigan Fish Contaminant Monitoring Program 2005 Annual Report available at http://www.deq.state.mi.us/documents/deq-wb-swas-fcmpreport2005.pdf.

have been detected with the available data for each species and station. The median minimum detectable trend for Great Lakes or connecting channel stations was +/-2.6% per year, indicating that any undetected changes were likely small. Also, species were collected at 13 inland lakes or Great Lakes tributaries (species varied by site). Mercury concentrations decreased in fish from five locations (median decrease of 3.2% per year), increased in fish from two locations (median increase of 5.8% per year), and trends were not detectable in fish from six locations. **Figure 6-11** includes the annual rate of change for mercury that includes the average and median concentrations calculated for the corresponding waterbodies along with the species that had significant trends.

FIGURE 6-11: ANNUAL RATES OF CHANGE IN MERCURY CONCENTRATIONS MEASURED IN WHOLE FISH (FROM FIXED STATION TREND MONITORING SITES)



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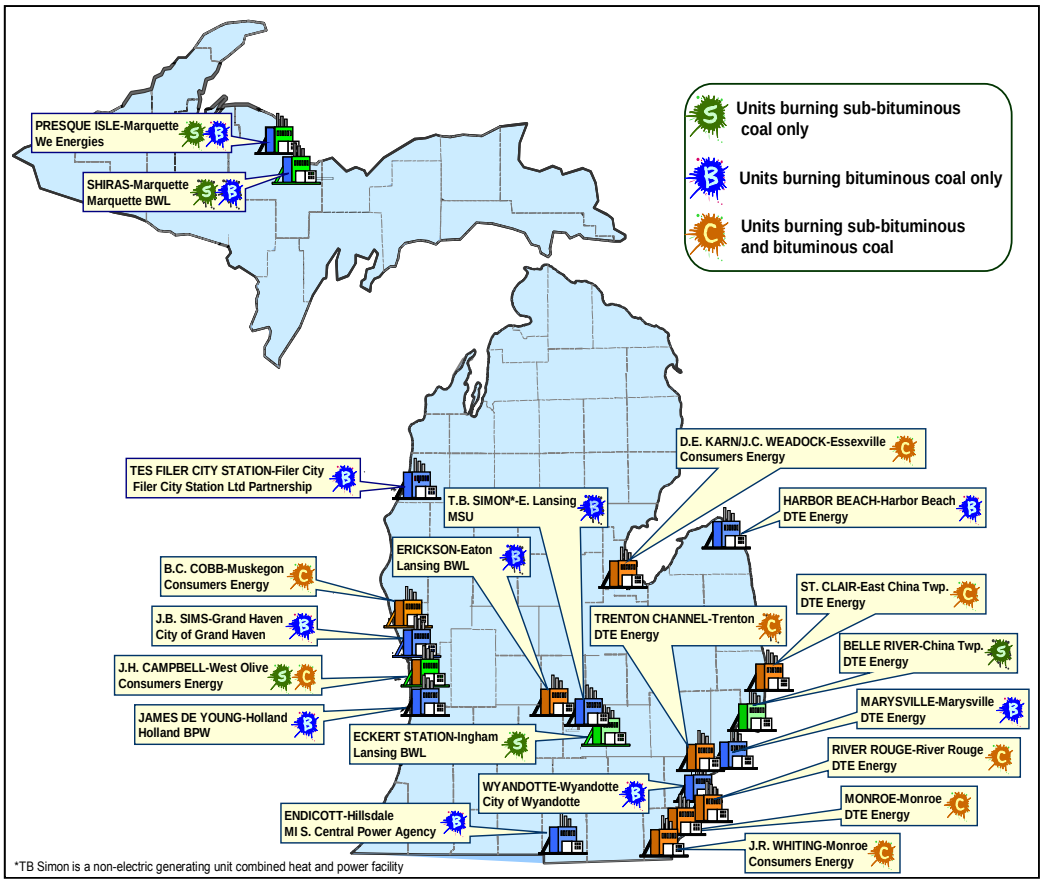
7. CONTROL TECHNOLOGY AND REMEDIATION TECHNIQUES

Control of mercury pollution sources has been investigated over the past two decades. Various mercury-specific and multi-pollutant control technologies have been reviewed for application on several source sectors. This chapter presents information on key aspects of mercury control approaches to coal-fired EGU emissions and emissions from other source sectors (descriptions for EGUs were primarily obtained from the *Michigan Mercury Electric Utility Report, 2005*). In addition, mercury control technologies currently used for treating mercury contaminated groundwater and soil are included. Also discussed is mercury removal from municipal WWTP effluent, and current practices and technologies available for separation of mercury-containing dental amalgam from sanitary wastewater.

7.1 AIR EMISSION CONTROL TECHNOLOGIES FOR EGU'S

Due to the nature of mercury emissions, mercury from Michigan EGUs can be deposited locally, regionally, and globally. Development of controls and optimization of existing controls for mercury removal is an on-going process. Currently, a number of technologies can be used to remove mercury from utility coal-fired EGU flue gas. These technologies fall into two broad categories: existing control technologies intended for control of other pollutants, which can be optimized for control of mercury; and mercury-specific control technologies. These technologies vary in terms of the mercury control they can achieve, the kinds of coal type and power plant configuration to which they are best suited, and the extent to which they have been deployed at the power plants. **Figure 7-1** shows the locations and the coal type burned in Michigan's EGUs (Michigan Mercury Electric Utility Report, 2005).

FIGURE 7-1: MICHIGAN'S COAL-FIRED EGUS



Although flue gas cleaning technologies to date have been employed to remove other air

pollutants, a percentage of mercury is also removed as a co-benefit. The amount of mercury removed can range from no removal to over 90% depending on mercury speciation (the chemical and physical form of mercury in the flue gas stream), the cleaning technology employed, and the temperature at which the cleaning technology is operated.

The following information reviews the technological options for mercury control, including existing pollution control devices for other pollutants, mercury-specific technologies, and emerging multi-pollutant technologies.

7.1.1 FLUE GAS CLEANING TECHNOLOGIES

A major factor in determining mercury control effectiveness is speciation in the flue gas. RGM and Hg(p) are more readily controlled by existing pollution control devices than Hg(0). In general, because of higher chlorine and lower calcium levels, eastern bituminous coals tend to produce more RGM than sub-bituminous coals. On a mass basis (measured as ppm in the coal), western sub-bituminous coals have a lower mercury content than bituminous coals. For blends of bituminous/sub-bituminous coal, preliminary results indicate units that burn appreciable amounts of bituminous coal (greater than 30%) have a large percentage of Hg(0) present in the flue gas converted to RGM. It is expected that a large portion of this converted mercury will be captured by downstream control devices for units burning blended fuels.

However, it should be noted that even though a coal may have less mercury content as compared to other coal types, there is not a direct correlation between the mercury content in the coal and what is emitted from the stack. Other variables which need to be considered when trying to establish this relationship include the chlorine content of the flue gas, the carbon content of the ash, the quantity of the mercury contained in the coal that is speciated into Hg(0), RGM, and Hg(p), and the type(s) or controls that are utilized for particulate matter (PM) control.

Flue gas cleaning technologies that have some applicability for mercury removal and are utilized by Michigan EGUs include the following:

- Selective Catalytic Reduction (SCR) or Selective Non-catalytic Reduction (SNCR) for NO_X (oxides of nitrogen) reduction.
- Electrostatic precipitator (ESP) (either hot-sided [HS-ESP] or cold-sided [CS-ESP]) and fabric filter for reduction of PM_{10} (PM with a diameter of 10 microns or less).
- Flue gas desulfurization (FGD) systems (wet and dry) use spray dryer absorbers for SO_X (oxides of sulfur) reduction.
- Wet and Dry SO_2 (sulfur dioxide) Scrubbers.

Table 7-1 shows the potential for mercury reduction as a co-benefit based on the type of combustion technology used, the type of coal burned, and the air quality control system technology used.[168] This table indicates average reductions observed on a limited test basis. Note: Most of the largest EGUs in Michigan use a combination of pulverized coal (PC) combustion technology, bituminous, sub-bituminous, or blended fuels, and CS-ESPs. Two of Michigan's EGUs use circulating fluidized beds (CFBs) with either SCR or SNCR.

[168] All the listed units burn either 100% bituminous, or 100% sub-bituminous coals.

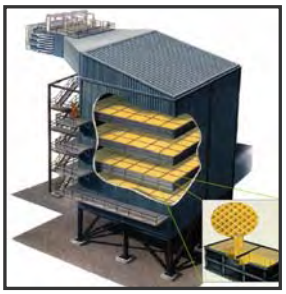
TABLE 7-1: POTENTIAL MERCURY REDUCTION AS A CO-BENEFIT

BOILER TYPE	COAL BURNED	AIR QUALITY CONTROL SYSTEM TECHNOLOGY UTILIZED			
		NO_X	SO_2	PM	Average % of Hg Removed
PC	Bituminous	-	-	CS-ESP	36
PC	Sub-bituminous	-	-	CS-ESP	9
PC	Bituminous	-	-	HS-ESP	14
PC	Sub-bituminous	-	-	HS-ESP	7
PC	Bituminous	-	-	Fabric Filter	90
PC	Sub-bituminous	-	-	Fabric Filter	72
PC	Bituminous	-	Dry FGD	CS-ESP	Not Tested
PC	Sub-bituminous	-	Dry FGD	CS-ESP	43
PC	Bituminous	-	Dry FGD	Fabric Filter	98
PC	Sub-bituminous	-	Dry FGD	Fabric Filter	25
PC	Bituminous	SCR	Dry FGD	Fabric Filter	98
PC	Sub-bituminous	SCR	Dry FGD	Fabric Filter	Not Tested
PC	Bituminous	-	Wet FGD	CS-ESP	81
PC	Sub-bituminous	-	Wet FGD	CS-ESP	29
PC	Bituminous	-	Wet FGD	HS-ESP	46
PC	Sub-bituminous	-	Wet FGD	HS-ESP	20
PC	Bituminous	-	Wet FGD	Fabric Filter	98
PC	Sub-bituminous	-	Wet FGD	Fabric Filter	Not Tested
CFB	Bituminous	SNCR	-	Fabric Filter	94
CFB	Sub-bituminous	SCR	-	Fabric Filter	57

Source: Staudt and Jozewicz (2003). CFB data from Kilgroe et al., 2002.

The following are brief discussions of the various flue gas cleaning technologies that are utilized by Michigan EGUs:[169]

SELECTIVE CATALYTIC REDUCTION (SCR) SYSTEMS



A SCR system uses a catalyst impregnated bed to reduce NO_X emissions. The catalyst in the SCR reactor can also oxidize a small percentage of Hg(0) to RGM, enabling the RGM to be captured in a downstream wet scrubber. Research to date on existing SCR systems has shown that oxidation does not occur to any appreciable extent with sub-bituminous coals, but occurs to a large extent with most bituminous coals and blends that have about 30% or more bituminous coal. The rate of mercury oxidation depends on the type of SCR catalyst, flue gas flow rate, flue gas temperature, and the reactive catalyst site (remaining catalyst life cycle). Ammonia, injected in a SCR system, somewhat inhibits the mercury oxidation process. Overall, SCRs absent a downstream scrubber have variable impact on mercury removal depending on the specific installation and fuel type used.

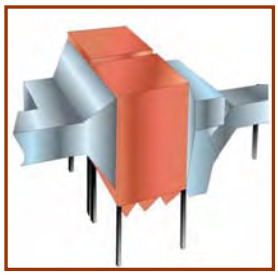
SELECTIVE NON-CATALYTIC REDUCTION (SNCR) SYSTEMS

A SNCR system is a post-combustion NO_X reduction method that reduces NO_X through controlled injection of a urea solution into the combustion gas path of fossil-fired and waste-fired boilers, furnaces, incinerators, or heaters. The resulting chemical reaction transforms NO_X, urea, and oxygen into molecular nitrogen, carbon dioxide, and water. The NO_X reducing reaction is temperature sensitive: by-product emissions become significant at lower than optimum temperatures and NO_X reduction decreases at higher

[169] These technology discussions draw largely on EPA's interim report (Kilgroe et al., 2002).

than optimum temperatures. It is not known if SNCR has any effect on mercury emissions.

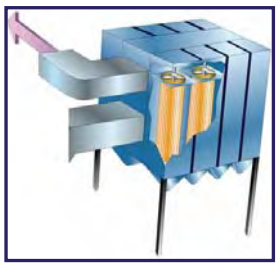
ELECTROSTATIC PRECIPITATORS (ESPS)



ESPs are high-efficiency particulate control devices that have been used to control PM emissions for over 80 years. ESPs operate by imparting an electrical charge to flue gas particles and then attracting the particles to oppositely charged metal plates. The collected particles are periodically discharged from the plates and collected in hoppers. The effectiveness of particulate capture depends mainly on the electrical resistivity of the particles. In general, fly ash produced from higher sulfur coals is efficiently captured by an ESP, while lower sulfur coals produce a higher resistivity ash that is harder to capture. However, alteration of boiler firing temperature or fly ash conditioning upstream of the ESP can optimize resistivity for particle collection. Particulates in the region of 0.3 micrometers (µm) are typically more difficult to control than larger particles. The ESPs installed are either HS-ESP or CS-ESP depending on whether the ESP is located upstream or downstream of the air heater. ESPs have the potential to remove most particulate and variable amounts of RGM (more in cases of higher unburned carbon levels in ash), but in general very little potential to remove Hg(0).

Recent EPRI, EPA, and DOE-funded research has shown that ESPs remove virtually all of the Hg(p) from flue gases. Depending on the chemistry and character of the fly ash and flue gas, some of the RGM and a smaller percentage of Hg(0) will be absorbed onto fly ash and removed by the ESP as the flue gases cool after leaving the boiler. Because of greater Hg(0) produced, western coals (sub-bituminous, bituminous, and lignite-type coals) tend to lead to smaller overall percent removal rates by ESPs. In contrast, plants equipped with ESPs, which burn eastern bituminous coals, tend to capture more mercury than similarly equipped plants which burn western coals. Based on the ICR (Information Collection Request) database, EPA found average mercury removal rates for a CS-ESP were 9% for sub-bituminous coal-fired boilers and 36% for bituminous coal-fired boilers. By contrast, the removal percentages for HS-ESPs were 14% and 7%, respectively (Staudt and Jozewicz, 2003).

FABRIC FILTERS



Fabric filters are high-efficiency particulate control devices that utilize a packing of fibers to intercept particles in the gas stream. Most fabric filters have one of two designs based on the cleaning method – either reverse-air or pulse-jet, with flue gas moving through the filter bags differently in each case. An advantage of fabric filters over ESPs for particulate control is relatively consistent control effectiveness across various fuel ash characteristics or particulate load (Lavely and Ferguson, 1996). Fabric filters are generally more effective than ESPs at controlling smaller particles (<0.3 µm) and have greater potential for increased mercury capture compared to ESPs, because the mercury can be adsorbed by entrained fly ash as well as directly by the filter cake on a fabric filter. Fabric filters remove virtually all of the Hg(p) and are generally more, but not completely effective in removing RGM and Hg(0) from flue gas. Based on tests at five units through the ICR, average mercury control effectiveness of 90% and 72%, respectively, were tested for units burning bituminous and sub-bituminous coals, respectively (Staudt and Jozewicz, 2003).

Fabric filter technology evolved and gained widespread utilization in the power plant

industry about a decade ago. Today, most new power plants utilize fabric filters or fabric filters in tandem with ESPs. In this latter hybrid set up, flue gas can first be passed through a smaller ESP to remove the majority of fine particulate ($PM_{2.5}$ or PM with a diameter of 2.5 microns or less), and then through a small, higher air-to-cloth ratio bag filter to more efficiently remove the residual particulates. However, virtually all of Michigan's coal-fired EGUs were built before the fabric filter technology was perfected and use is currently limited to 13 Michigan units (Michigan Mercury Utility Report, 2005).

While new plants can employ fabric filter technology alone or in combination with ESPs at reasonable costs, it can be costly for existing units to be retrofitted with fabric filters. The pressure drop across a fabric filter is substantially higher than the pressure drop across an ESP. For newly built plants, boilers, ductwork systems, and fans are designed for a total system pressure drop, which is set by the various components in the system. When a new component is added to the system and the total system pressure drop increases, there is the potential for collateral impacts on the structural elements of the boiler, air heaters, and ductwork, which can result in extensive structural modifications. Likewise, the unit's induced draft fans must be modified, supplemented by booster fans, or replaced all together to provide for adequate pressure capability. These modifications result in a substantial capital investment which is collateral to simply adding a fabric filter as a new piece of equipment, driving up the total cost of the fabric filter installation.

FLUE GAS DESULFURIZATION (FGD) SYSTEMS

FGD systems use dry or wet spray to absorb SO_2 gas and form dry particles that are collected in a particulate control device. Dry FGD systems include dry scrubbers and CFB absorbers, the latter of which is integrated with the combustion technology. A calcium-based slurry/sorbent is injected into the reaction vessel where the flue gas reacts with the drying slurry droplets.

Wet FGD systems or wet scrubbers use a liquid absorbent to absorb SO_2 gas. The liquid is typically an aqueous solution containing an alkaline chemical that reacts with the SO_2 to form insoluble salts that are then removed from the scrubber effluent. Most wet FGD systems for SO_2 control use either limestone or lime as the alkaline source. Parameters that effect SO_2 removal efficiency include liquid-gas ratio, pH of the scrubbing medium, and ratio of calcium sorbent to SO_2.

Mercury capture in FGD systems is species dependent. FGD systems in general have the potential to remove Hg(p) and RGM to relatively high extents. RGM is generally water soluble and can absorb in the aqueous solution of a wet FGD system. Because Hg(0) has low water solubility, its removal would only occur to the extent that it is adsorbed on either fly ash or added slurry/sorbent, which would typically be relatively limited. For bituminous coals, higher capture of all three species would typically be expected in dry FGD units that are followed by fabric filters. Also, testing has shown potential for re-emission if the chemistry of the wet FGD favors the conversion of RGM to Hg(0).

As part of the ICR Part III data collection activities, several power plants equipped with dry SO_2 scrubbers were tested. According to EPA, the efficacy of this control configuration to capture mercury is quite variable. The variability is a function of both coal rank and the particulate control device used. For example, for a bituminous coal-fired boiler equipped with a fabric filter, 98% of the mercury was captured, while for sub-bituminous coal-fired boiler equipped with an ESP, mercury control (across the control device) was down to 43%. Mercury control effectiveness of dry scrubbers for units

burning sub-bituminous coals was consistently lower, whether or not the units were equipped with CS-ESP/spray dryer absorbers. The low removal rates for the three plants tested (Craig and Rawhide [Colorado], and NSP Sherburne [Minnesota]) may have been due to low coal chlorine levels, which would have contributed to very high fractions of Hg(0) in the flue gas [EPA, 2001c].)

Dry and wet scrubbers can also be used at other combustion sources. It is important to note that there will be some scrubber retrofits in Michigan within the next decade and these can be expected to reduce RGM emissions.

7.1.2 MERCURY-SPECIFIC CONTROLS

Technologies designed specifically or in part for mercury control are at various stages of development. In 2006, the DOE's National Energy Technology Laboratory (NETL) was awarded four patents for cleaner, efficient fossil fuel use.[170] The NETL patents include a hybrid engine system, a process for saving energy at power plants, a method for capturing mercury from power plant flue gases, and a device to detect instability in combustion systems.

There is also a range of technologies that are being used extensively in other industries and already in pilot implementation at power plants, from more minor modifications of existing technologies, to truly novel experimental technologies.[171] Two reports from the DOE NETL and the EPA Office of Research and Development summarize test results on mercury control technologies at coal-fired EGUs (Feeley et al., 2003; EPA 2005a). However, it is important to note that the application of mercury controls introduces increased mercury concentrations into other waste streams from the control devices which must be properly managed.

The following discuss various mercury-specific control technologies that are currently available or are anticipated to become available soon.

ESP MODIFICATION/SO_2 SCRUBBERS

Low temperature catalysts that can be installed within an ESP or in the duct downstream of an ESP or fabric filter, are being evaluated as a means to convert Hg(0) to RGM and thereby allow existing or planned wet SO_2 scrubbers to collect Hg(0) as well as RGM. Low temperature catalysts appear to be a more cost-effective technology being developed for retrofit applications in the near term. This option is limited to plants that have or are going to install SO_2 removal equipment. Cost information is not yet publicly available on some of the proprietary catalysts being tested.

In addition, proprietary reagents are being tested for use in existing scrubbers to help retain captured RGM in scrubber sludge. During the ICR measurement program, as well as during subsequent measurement work conducted by EPRI and DOE, researchers observed that some of the captured RGM was re-emitted as Hg(0). While the actual nature of these apparent reduction reactions remains undefined, it is believed that the reactions involve sulfur species. Cost information is not yet publicly available for these proprietary chemicals nor for the chemical storage tanks and injection equipment they would require.

[170] Details on these patents are available at http://www.netl.doe.gov/publications/press/2007/07009-NETL_Awarded_Four_Patents.html

[171] More information is available at http://www.netl.doe.gov.

SORBENT INJECTION

One of the most promising technologies for add-on mercury control at coal-fired EGUs is sorbent injection. This involves injection of a sorbent material (typically in powdered form) in the flue gas upstream of a particulate collection device. Activated carbon has gained the most attention. In powdered form the sorbent provides the necessary surface for adsorption of mercury species. Any sorbent will be more effective when injected upstream of a fabric filter because of the additional opportunity for mercury removal as the flue gas passes through the filter cake. Coal fly ash itself, depending upon its carbon and other mineral content, may also act as an effective adsorbent if fabric filter technology is employed. Lime (in the event the plant utilizes dry scrubbing) and the impurities associated with lime may also potentially absorb some RGM.

There are generally two types of ACIs (activated carbon injection), standard ACI and chemically treated ACI. Chemically treated ACI generally has halogens added to the carbon which have a similar oxidizing effect to chlorine in the flue gas and are believed to be more effective in removing mercury from low chlorine sub-bituminous coals.

One proprietary version of sorbent injection involves the TOXECON™ technology developed by the EPRI. The process involves injection of powdered activated carbon into a pulse-jet fabric filter installed downstream of the existing particulate collection device. A demonstration of this approach is in progress at the We Energies Presque Isle Power Plant and the *TOXECON™ Retrofit for Mercury and Multi-Pollutant Control on Three 90-MW Coal-Fired Boilers Preliminary Public Design Report* was released.[172]

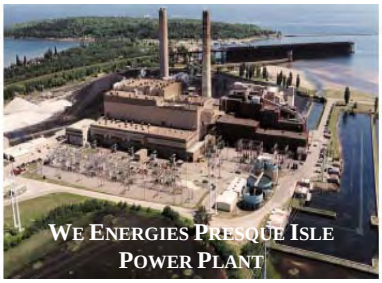

WE ENERGIES PRESQUE ISLE POWER PLANT

Table 7-2 summarizes full scale field tests that have been performed at coal-fired EGUs utilizing powdered ACI for mercury control (Michigan Mercury Utility Report, 2005). Mercury reduction is given as upper limits, where the reduction percentage has started to level off with additional carbon injection. Mercury reduction on the low end will vary based on the coal type (for native mercury reduction – i.e., without sorbent injection), the add-on technology, and the type and amount of sorbent injected. For units without fabric filters, the combination of standard carbon and bituminous coal has been shown to require approximately 20 lbs/MMacf (pounds of carbon per million actual cubic feet of flue gas) to reach 90%, while minimal increase in reduction (beyond about 70%) was seen for standard carbon and sub-bituminous coal beyond about 5 lbs/MMacf. In contrast, brominated carbons have been shown to be more effective at controlling Hg(0) emissions. Some testing has shown control levels of 90% or greater, while other tests indicate control levels of approximately 70% (EPA, 2005a).

TABLE 7-2: MERCURY CONTROL EFFICIENCIES WITH POWDERED ACI IN FULL-SCALE TESTS AT COAL-FIRED EGUS

POWER PLANT NAME (STATE)	COAL TYPE	EXISTING CONTROLS	ADD-ON TECHNOLOGY	MERCURY REDUCTION	REFERENCE
Alabama Power – Gaston Unit 3 (AL)	bituminous	HS-ESP	ACI and COHPAC* Fabric Filter	Up to 90%	Bustard et al., 2002
Southern Co. – Yates Units 1, 2 (GA)	bituminous	CS-ESP	ACI	Up to ~75%	Richardson et al., 2004
PG&E – NEG Brayton Point Unit 1 (MA)	bituminous	Two CS-ESPs	ACI	Up to 90%	Durham et al., 2003a

[172] The report is available at http://www.netl.doe.gov/technologies/coalpower/cctc/ccpi/pubs/RP-05-0148-R2%20Preliminary%20Public%20Design%20Report.pdf

TABLE 7-2: MERCURY CONTROL EFFICIENCIES WITH POWDERED ACI IN FULL-SCALE TESTS AT COAL-FIRED EGUS

POWER PLANT NAME (STATE)	COAL TYPE	EXISTING CONTROLS	ADD-ON TECHNOLOGY	MERCURY REDUCTION	REFERENCE
WEPCO – Pleasant Prairie Unit 2 (WI)	sub-bituminous	CS-ESP	ACI	70% (long-term)	Durham et al., 2003b
Sunflower Electric's Holcomb Station	sub-bituminous	Spray dryer absorbers, fabric filter	ACI – several sorbent types	Up to 90%+	Sjostrom et al., 2004
DTE Energy - St. Clair Power Plant (MI)	85/15 sub-bituminous/ bituminous	CS-ESP	Brominated ACI	Over 90%	Nelson et al., 2004
Leland Olds Station Unit 1 (ND)**	lignite	Two parallel CS-ESPs	ACI	63% (average for month-long test)	Thompson et al., 2004
Great River Energy–Stanton Unit 10 (ND)	lignite	Spray dryer absorbers, fabric filter	ACI – Untreated; Iodine-impregnated	Up to 81% Up to 96%	Sjostrom, et al., 2002

*COHPAC is Combined Hybrid Particulate Collector (patented type of fabric filter).

**Note: Leland Olds test target mercury removal rate was only 55%, carbon injection rate was adopted accordingly.

Another important consideration in ACI with only ESP particulate control is the ESP size. Coal-fired boilers have variably sized precipitators. The Specific Collection Area (SCA) describes the relative size of a precipitator, and is used to estimate the collection efficiency. The SCA is calculated as the total collector plate area divided by the gas volume flow rate (and thus has units of time/length). Before SO_2 control requirements were added in the CAA Amendments of 1977, many Michigan plants burned higher sulfur coal that produced fly ash, which was more easily captured by an ESP. Power plants built before this time typically had smaller precipitators with SCAs of 200 or less. The ease with which power plant ash is captured by a precipitator is a function of the chemical makeup of the ash and the SO_2 content of the flue gas. Eastern high-sulfur coal produces flue gas with higher SO_2 concentrations and ash with lower resistivity. After 1980, Michigan mandated lower SO_2 emissions and power plants in Michigan generally found that switching to lower sulfur coal, rather than installing scrubbers, was more economical to meet the lower SO_2 mandate. However, with the combustion of lower sulfur coal, many plants have found that their existing precipitators are functioning much closer to a particulate compliance limit. This is important when considering whether the particulate loading to an ESP or the resistivity of the fly ash can be further increased. ACI may change the resistivity of ash and increase particulate loading to the existing ESP, both potentially making PM control more difficult. Units that have an ESP with less than 300 SCA, particularly units that burn sub-bituminous coals or blends containing sub-bituminous coals, may not perform properly from a particulate removal perspective if activated carbon is injected. EPA has published a study that characterize coal combustion residue and other enhanced sorbents for reducing air emissions of mercury, and the potential for leaching of captured mercury during the disposal or use of these residues (EPA, 2006f)

An important consideration with ACI is that regardless of what type of control is implemented, permanent capture is needed to assure that the mercury will not simply be moved from one environmental media to the next. For example, studies on the stability of mercury retained in the fly ash and gypsum has demonstrated that the mercury appears to be relatively stable depending on a variety of factors (Gustin, et al., 2006). These by-products (fly ash and gypsum) can be reused.

UTILITY BY-PRODUCTS

Coal-burning EGUs, which supply more than half of U.S. electricity, also generate coal combustion by-products. The reuse of coal combustion process by-products is not a

new concept. The Romans used product similar to coal ash, volcanic ash, to construct the Coliseum, aqueducts, and other structures that remain today. Coal ash has been commercially used in concrete in both Europe and the U.S. for more than 60 years. As an example, between 1948 and 1953 over 120,000 metric tons of fly ash was used in the construction of Hungry Horse Dam in Montana. As a local example, DTE Energy ash was used in the construction of the Mackinac Bridge.

Table 7-3 was generated from the Energy Information Administration Form 767 for the year 2001 that identifies coal combustion and FGD by-products that were recycled/reused. For each ton of material reused, not only is there a large financial swing from an expense to a revenue stream, but there are secondary impacts on the environment. Using ash as an example, although a variety of re-uses exist or are in development (see **Table 7-4**), the majority of recycled ash is used in the manufacture of cement or concrete. For each ton of ash replacing a ton of cement in the manufacture of concrete, over a barrel of oil is saved, there is a reduction in greenhouse gases such as carbon dioxide, and landfill space is saved (USGS, 2002).[173] These secondary environmental benefits can be significant. The amount of space require to dispose of one ton of coal ash is equivalent to that required for the solid waste produced by an average American in a 455-day period.

TABLE 7-3: 2001 COAL COMBUSTION AND FGD BY-PRODUCTS RECYCLED/REUSED

FORM 767 DATA	ASH TONS RECYCLED	ASH RECYCLED REVENUE $	FGD SLUDGE TONS RECYCLED	SLUDGE RECYCLED REVENUE $
U.S.	23,399,100	$19,231,900	6,535,000	$26,107,500
Michigan	599,800	$2,006,000	0	$0

TABLE 7-4: SALEABLE BY-PRODUCTS

MATERIAL	COMMON AND DEVELOPING RE-USES	
Ash	Admixture in the concrete Feedstock in production of cement & asphalt Flowable fill Sludge and waste stabilization Reuse in energy production Reclamation and neutralization of waste coal abandoned mine sites Combine with sludge from industrial lagoons and waste from hog farms Highway roadbeds Structural fill in embankments or under buildings (e.g., malls) Inert clinker for roads (when stabilized with cement)	High quality grit blasting media Cast brick and block Low density aggregate Roofing tiles Glass products Fertilizer Extruded high strength bricks Extruded wall panels Light-weight aggregate Filler materials Extruded masonry blocks with two-way joints Coloring aggregates for asphalt Manufacture of magnesium Highway sound barrier walls and privacy walls
FGD	Gypsum; Agricultural soil stabilizer; Inert fill	

Anytime by-products are used in lieu of another natural material, like soil, sand, or gypsum, a portion of the fossil energy required to mine, transport, place, or process is reduced. For example, using coal ash instead of natural soil in the construction of highway fills or embankments eliminates the need to remove soil from undisturbed areas, saving energy. As another example, the use of FGD synthetic gypsum provides material to manufacture wallboard, avoiding the energy intensive mining and processing activities when natural gypsum is used. If mercury control technology negatively impacts the reuse of by-products (e.g., if activated carbon is injected upstream of an ESP), it would eliminate many of the environmental benefits mentioned above.

[173] The USGS Fact Sheet 076-01 is available at http://pubs.usgs.gov/fs/fs076-01/fs076-01.html.

An additional concern is the fate of mercury captured via pollution control devices. There has been some concern that ACI for mercury control could make ACI-contaminated fly ash a hazardous waste, or at a minimum that mercury could potentially be leached from the fly ash. Research to date using standard test procedures has shown relatively limited leaching of mercury from fly ash and FGD materials; however, researchers note that additional tests on release rates, leachability, and potential impacts of mercury from a wider variety of fly ash, sludges, and other materials are needed (Pavlish et al., 2003).

7.1.3 CONTROL TECHNOLOGIES AND SMALL EMITTERS

There has been a relatively small number of slipstream or full-scale tests to date on mercury control at smaller units [<80 Megawatt (MW)]; some smaller units evaluated include the Endicott Station in Michigan, as well as Abbott No. 5 (Illinois), Cliffside No. 2 (North Carolina), Stanton No. 10 (North Dakota), and Valley No. 3 (Wisconsin). Due to lack of economies of scale, control costs could be higher for smaller plants. While mercury-specific control requirements could be waived for smaller units (i.e., below a certain emission or capacity threshold), because of the potential for more substantial emissions from multiple units at a single plant, this determination may need to be made on a case-by-case basis for feasibility and cost.

7.1.4 NEW MULTI-POLLUTANT CONTROLS

Several new air pollution control systems are currently under development and testing. These new systems will integrate established and emerging technologies into a single system that will be capable of removing multiple pollutants (SO_2, NO_X, $PM_{2.5}$, and mercury) for future coal-fired plant applications. In addition to the environmental benefits of reducing multiple pollutants, there could be potential economic benefits as well, if the multi-pollutant approaches can achieve equivalent or greater reductions at costs less than the those of combined costs for SO_2 and NO_X control (e.g., typically $250 to $300 per kilowatt for a combined SCR and wet scrubber installation). True one-component multi-pollutant control technologies include the following.

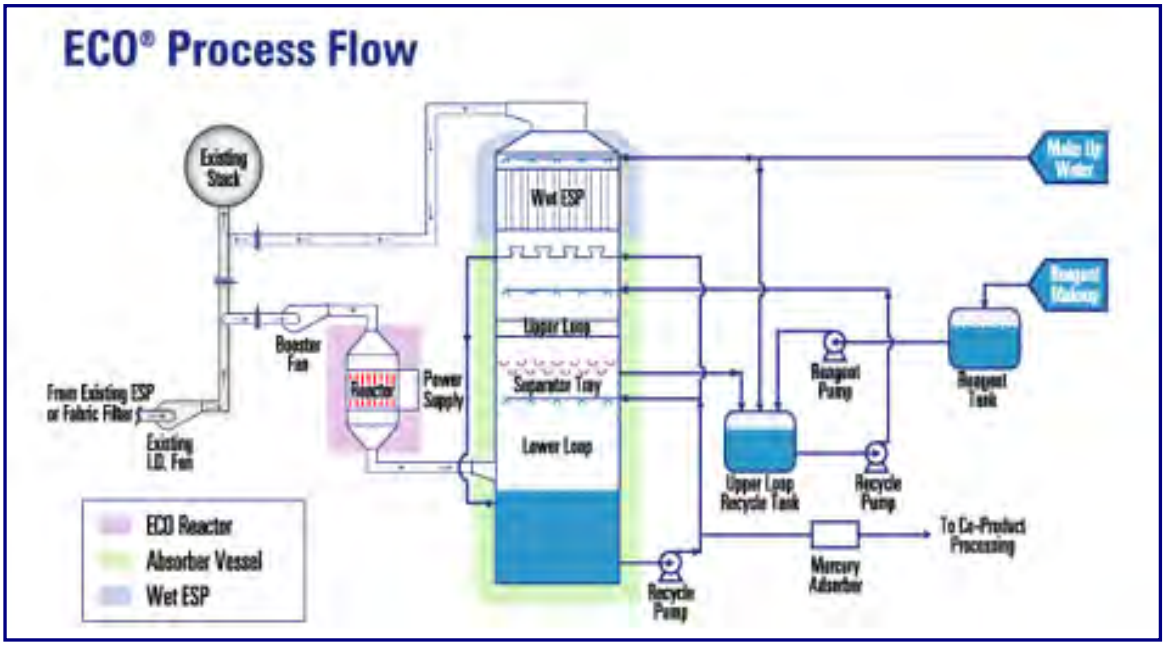
ELECTRO-CATALYTIC OXIDATION SYSTEM (ECO)

The ECO system is a four stage pollution control process developed by PowerSpan (see **Figure 7-2**) that is designed to remove SO_X, NO_X, and mercury from high sulfur coal. The key component is a reactor in which NO_X and mercury are oxidized into collectable species by ozone oxidation. The oxidized species are then scrubbed by ammonia and the cleaner gas flows to a wet ESP for aerosol removal. The scrubbed product is further treated by chemicals to produce a commercially saleable ammonium sulfate nitrate fertilizer co-product. The system reduces operating costs and also avoids landfill disposal.

The ECO system is currently in field demonstration testing.[174] It has been undergoing pilot testing in a 1 to 2 MW slipstream unit at First Energy's R.E. Burger Plant since February 2002 and a 50 MW ECO commercial demonstration unit was added in 2004. The ECO system has shown to provide 98% reduction of SO_2 emissions, 90% of NO_X emissions, 80% to 90% of mercury emissions, and 95% of $PM_{2.5}$ emissions.

[174] The report *Mercury Removal In A Multi-Pollutant Control Technology For Utility Boilers* is available at http://www.netl.doe.gov/technologies/coalpower/ewr/mercury/control-tech/pubs/AQ%20III%20ECO%20Paper.pdf

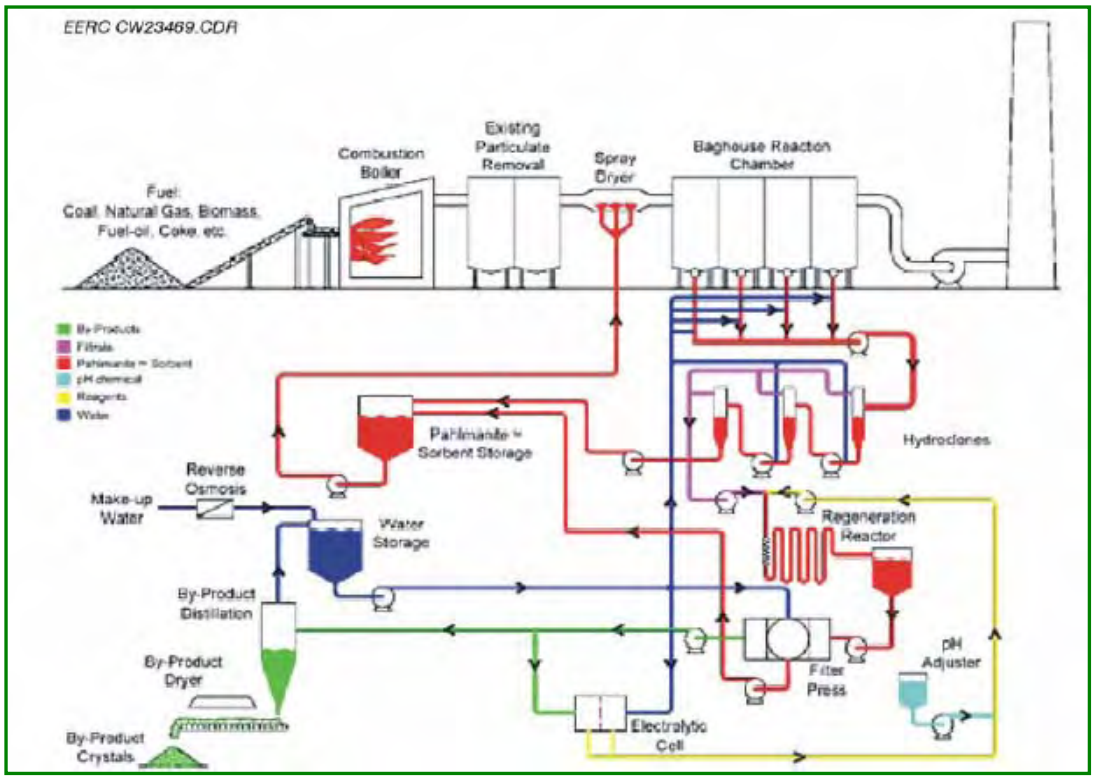
FIGURE 7-2: THE ECO SYSTEM



PAHLMAN PROCESS

EnviroScrub Technologies Corporation has developed the Pahlman Process of multi-pollutant control (see **Figure 7-3**). This process is claimed to provide removal efficiencies of over 99% for NO_X, 99% for SO_2, and 60% to 70% for vapor phase mercury (Hg(0) and RGM). Hg(p) is removed in the upstream ESP/fabric filter. The Pahlman process by-products (waste) are sodium sulfate, ammonium nitrate, and potassium sulfate.

FIGURE 7-3: THE PAHLMAN PROCESS



EnviroScrub estimates a Pahlman installation would cost about 30% to 50% less to construct, operate, and maintain over a 20-year life cycle than the combined cost of the alternative combination of a wet scrubber, SCR, and ACI for SO_2, NO_X, and mercury control.[175] The Pahlman process provides power plants the flexibility of selecting whatever coal is economical.

EnviroScrub offers mobile onsite demonstration of their technology. The mobile unit is built on a 48-foot semi-trailer and it can be transported virtually anywhere in the U.S. or Canada. The unit is able to scrub emission flows ranging from 500 to 2,000 cfm. Nooter/Eriksen has been licensed to design, supply, and install the Pahlman Process in North America.

AIRBORNE PROCESS

Airborne Pollution Control Inc. has partnered with Babcock & Wilcox, U.S. Filter, and the LG&E Energy Corporation to conduct the first ever field testing of its proprietary multi-pollutant control process. This technology will remove NO_X, SO_2, mercury, and other heavy metals. Claimed reductions for SO_2, NO_X, and mercury are 99%+, 95%+, and 95%+, respectively. The scrubbing agent used to remove the pollutants is sodium bicarbonate. Although this is an expensive reagent, the product of the sodium bicarbonate SO_X reaction (sodium sulfate) is recycled back into sodium bicarbonate and a sulfate-based fertilizer co-product is produced.

7.1.5 NEW SEMI MULTI-POLLUTANT CONTROL TECHNOLOGIES

The following information describes a few technologies being developed that are combined with existing technologies to provide multi-pollutant controls.

PLASMA-ENHANCED ELECTROSTATIC PRECIPITATORS (PEESP)

The PEESP technology, developed by MSE Technology Applications and Croll-Reynolds Clean Air Technologies, combines existing ESP technology with low energy plasma technology. An injector electrode-type corona discharge to standard air pollution control equipment is the basis of the PEESP. Conventional wet ESPs are quite effective at reducing particulate emissions, but are not effective at removing gaseous pollutants, such as mercury, NO_X, and SO_X. However, by modifying the central electrode to inject a reagent gas through the corona discharge, a standard wet ESP (coaxial cylinders design) can be effective at removing Hg(0) and potentially other trace contaminants. The PEESP extends the collection capabilities of a dry ESP/FGD scrubber or a FGD/Wet ESP system to include mercury removal as a collateral. However, such a technology would have limited applications for units burning sub-bituminous coals/blends, due to the production of cementatious ash.

RJM – BEAUMONT

The RJM Innovative Energy Solutions offers the RJM-Beaumont process and when it is combined with their RJM-LTTM (layered technology) NO_X reduction system, they claim it removes 99%+ of SO_2, 90%+ of NO_X, and 90%+ of mercury. The RJM-LTTM system is installed upstream of the RJM-Beaumont system and removes NO_X from the flue gas stream. The flue gas then enters the RJM-Beaumont CFB reactor. Lime slurry is injected into the reactor and SO_2 is removed. A fabric filter/ESP is installed downstream of the reactor to collect ash and dry slurry particles.

[175] An Enviroscrub presentation, *Mercury Removal Results from Two Coal-fired Utility Boilers* is available at http://www.netl.doe.gov/publications/proceedings/04/HgReview/EnviroScrub%20NETL-DOE%20Presentation%207-14-04.pdf.

7.1.6 NEW COAL TECHNOLOGY

There are various clean coal options available for meeting Michigan's future power needs, one of the most promising is integrated gasification combined-cycle or IGCC. EPA has undertaken several initiatives to facilitate and provide incentives towards the development and deployment of this technology (EPA, 2006e). IGCC technology offers an additional option for reducing emissions of mercury (and other pollutants). These plants involve the gasification (rather than combustion) of coal, and the subsequent driving of combustion and steam turbines. Though the basic coal gasification technology was first developed over 200 years ago, most application of the technology worldwide has been in industrial settings rather than electricity generation. IGCC has been demonstrated on a commercial scale for over ten years, although additional details regarding availability, reliability and costs need to be better defined (Black and Veatch, 2007). Another benefit to IGCC plants is that it has several significant advantages over other options regarding carbon capture (Black and Veatch, 2007). There are currently two operating IGCC plants in the U.S. – the Tampa Electric Polk Power Station in Florida and the Wabash River Repowering Project in Indiana. The technology may ultimately deliver efficiencies in the 50% to 60% range, and capture of most pollutants is easier than in combustion technologies. The DOE's Clean Coal Technology Program is demonstrating IGCC technologies, and recent innovations have improved both the performance and economics of IGCC units (Stiegel and Maxwell, 2001).[176] IGCC units hold substantial promise for the distant future and supercritical PC units with the most advanced turbines hold the best promise for the immediate future. In addition to new plants using coal more efficiently, new plant designs emit fewer pollutants per pound of coal.

7.1.7 OTHER COMBUSTION SOURCES

Many of the controls described for EGUs are also used for other combustion sources including cement kilns and sewage sludge incinerators. For example, the Ypsilanti Community Utilities Authority now operates a fluidized bed incinerator with venturi and impingement scrubbers, wet ESP, and carbon adsorption. The predicted maximum potential emissions from this updated facility are approximately 5 lbs/yr.

HOSPITAL MEDICAL INFECTIOUS WASTE INCINERATOR/MUNICIPAL WASTE COMBUSTORS

Technology to control mercury emitted from Hospital Medical Infectious Waste Incinerator/Municipal Waste Combustors have been in use for over a decade. Carbon injection followed by fabric filters has been used for years to achieve the mercury reductions required by the New Source Performance Standard (NSPS) promulgated under Part 129 of the CAA. This technology has been shown to be capable of achieving up to 95% control of mercury emissions in some cases and is currently being used in Michigan at a municipal waste combustor. More of the mercury is released as RGM rather than Hg(0) which increases the efficiency of the controls.

STEEL INDUSTRIES

For the steel making industries, the main sources of mercury are from fuel combustion (coke, natural gas, blast furnace gas, and coke oven gas) and from melting steel scrap containing mercury switches. Mercury switches are present in automotive scrap from vehicles manufactured in the 2003 model year and prior, and also in scrap from appliances and other "white goods." These sources include chest freezers, which may contain switches used in convenience lights on the lids; washing machines, which may

[176] Additional information on 24 IGCC power plants proposed for development are available at: http://www.netl.doe.gov/coal/refshelf/ncp.pdf.

contain switches on interrupter sensors on lids and dynamic stabilizing systems; gas stoves, furnaces, and hot water heaters, which may contain mercury switches in pilot light flame sensors and thermocouples; and sump and bilge pumps, which may use mercury switches in float sensors. The various sources of mercury emissions from scrap melting are BOFs, EAFs, EIFs, and steel cupolas. There are no known control technologies in use for mercury emissions from combustion sources at steel manufacturers. The best available method for control of mercury from scrap melting is through a scrap management plan. Such plans usually involve contractual agreements with scrap providers to remove all mercury switches from vehicles prior to shipping the scrap, documentation of the switch removals, provisions for cancellation of contracts with scrap recyclers who don't properly remove switches, and visual inspections of the scrap upon receipt by the facility. These plans have been included in most recent permits for sources that melt scrap steel in Michigan. A federal NSPS for EAFs was finalized on December 28, 2007 that requires scrap management plans for all EAFs in the U.S. (see **Table 3-2** in **Chapter 3.1.1**)[177]

CONTROL DEVICES AT CREMATORIES

Selenium Capsules: The Emcoplate Company from Sweden has developed the QuickSafe method for mercury removal. This method involves placing a QuickSafe ampoule atop the container prior to cremation. The ampoule contains selenium which is gasified during the cremation as the mercury is gasified. The selenium reacts with the mercury to form mercury selenide (HgSe) that will form crystals upon cooling and can then be collected via a baghouse, although the company's literature suggests that the HgSe could be emitted uncontrolled without negative environmental impacts. Testing results have shown up to 98% conversion/collection efficiency with this method. There is the issue of adding selenium, another toxic metal, into the exhaust stream of the crematory. Toxicity data is lacking for HgSe, but the compound would be considered a Hazardous Air Pollutant under Part 112 of the CAA as both a mercury compound and a selenium compound. One ampoule is required for a cremation, and the price per ampoule in 2002 was around $21.

Wet and Dry Scrubbing: There is only one crematory in the U.S. known to have wet scrubbers installed, which is at the Woodlawn Cemetery in the Bronx, New York. Testing was performed there in 1999 showing average mercury emissions of 1 g per cremation with a control efficiency of about 30%, although the report did not specify the number of fillings present in any of the bodies, the amount of mercury found in the scrubber water, or the speciation of the mercury. Wet scrubbing has been shown to remove mercury from the exhaust streams of other various processes, but the chemistry is such that only particulate and ionic mercury will be controlled, with very little effect on MeHg. Also, there was no information on the cost of the control system.

Miltec, a Norwegian firm, has developed a wet scrubber system with additive oxidizing agents for removal of mercury, sulfur, and particulates from crematories that has also been applied to waste incinerators and smelters. The company's literature claims a 90% guaranteed mercury control, with up to 98% efficiency possible. No data is readily available on cost.

No cases of carbon injection/fabric filter technology were found being used on crematories, although it would seem technologically feasible, as the methods of incineration for crematories are similar to those of medical waste incinerators.

[177] The EAF final rule to 40 CFR, Part 63, Subpart YYYYY was published in the December 28, 2007 FR (72 FR 248).

Other Controls: Vermeulen Product Engineering has developed a catalytic system, preceded by a cyclone and filter for dust removal, for control of mercury as well as dioxins and furans. The company's literature claims 99.8% control efficiency in removing mercury. Data from an existing crematory report says this system would cost $300,000 to retrofit to an existing crematory and $175,000 on a new crematory. It is important to note that a new crematory costs about $80,000.

Tooth/Filling Removal: The most cost-effective and efficient method for control of mercury from crematories would be the removal of either the amalgam fillings or the whole tooth with the filling prior to incineration. However, this method has been vigorously opposed when presented as many people considered this a desecration to the body of the deceased.

In 2003, the Washington State Department of Ecology required filling removal as a draft permit condition and was immediately denounced by local business groups. The Association of Washington Businesses and the Washington State Funeral Directors Association intervened in the permit negotiations and the draft condition was removed.

A poll taken by a Norwegian newspaper found that of 221 respondents, 40% were for filling removal and 53% were opposed, with 7% having no opinion. In the document summarizing comments received on the draft United Kingdom regulations, there were six main conclusions to the assessment, one of which was that removal of teeth or fillings is not acceptable. However, all listed comments received for the draft on the subject of filling removal recommended removal of fillings. A Swedish government report from the Chemical Inspectorate recommended removal of teeth as a control measure, but there was no report on the Swedish public's reaction. Public reaction to the Maine proposal for amalgam removal was overwhelmingly negative, with 72% opposed to the idea.

Environmental groups have pressed for tooth removal as a simple solution rather than add-on control. Most crematory operators are against removal because it would most likely be their responsibility to find a dentist or orthodontist to perform the procedure. So if filling removal were to be a required control method, it would have to be performed at a morgue or mortuary as part of the embalming or autopsy process prior to transporting the deceased to the crematory, perhaps under the direction of the Department of Community Health. State law requires embalming to be performed by a licensed mortician only with approval from the relatives of the deceased, but not before obtaining permission from the county medical examiner if cause of death has not been determined. This would mean that under current law, permission from the family of the deceased would be required for removal of the amalgam prior to cremation.

Interestingly, current cremation practices require removal of other implants, such as artificial limbs, defibrillators, and pacemakers, prior to cremation as a safety measure. State laws in Texas, South Dakota, and Wyoming require removal of hazardous implants prior to cremation, although the Wyoming statute expressly forbids removal or possession of "dental gold or dental silver from deceased persons." So another method for requiring removal of fillings would be to require removal of hazardous materials from the deceased prior to cremation, and have the amalgam be considered hazardous. No data was found on the cost of filling removal, although the state employment vacancies webpage lists dentists' wages from $34 to $46 per hour. The Sierra Aftercare Center in California charges a fee of $50 for removal of a pacemaker prior to cremation. Michigan does not currently have any regulations in place for removal of mercury dental amalgams prior to cremation.

7.1.8 NON-COMBUSTION SOURCES

Various sources can emit mercury because mercury has been added to a product that is being manufactured or processed for waste management. Such sources can include mercury switch or relay manufacturer, fluorescent light recyclers and fluorescent light drum crushers, autoclaves that process medical waste, and metal scrap shredders.

Hg(0) emitted from such sources as fluorescent light recyclers or autoclaves can efficiently be controlled by carbon filters. Effectively, 90-100% of the mercury can be captured through the application of various types of carbon adsorption control systems (EPA, 1994; Batdorf et al., 2005). A combination of waste management plans that outline what waste is acceptable for processing in addition to effective control technology should achieve efficient capture of mercury emissions from these sources. Autoclaves and fluorescent light recyclers currently require mercury controls at Michigan facilities. Conditions for Hg(0) capture from fluorescent light drum crushes in included in **Appendix S**. For metal shredders, Michigan currently has five existing shredders that include mercury conditions in their air permits. These conditions include stack testing, proper removal and disposal of mercury-containing devices to be shredded, and requirements for recordkeeping.

7.2 GROUNDWATER

Most of the methods for treating groundwater contaminated with mercury are pump and treat methods. The water must be drawn out of the ground and then passed through remedial processes before being returned to the environment. The following are some examples of remedial processing used to treat groundwater.

BIOENGINEERED BACTERIA

Bacteria are being designed that can remove mercury from groundwater (Betts, 1999). Modified *Escherichia coli* would be able to absorb large amounts of RGM without dying. The development of the bacteria is still in progress, but experiments have shown it is possible for the bacteria to clean groundwater to meet drinking water standards.

COPPER AMALGAMATION

The use of copper in permeable reactive barriers could help to remediate groundwater. Placing elemental copper in a water solution containing RGM will result in amalgamation, creating a mercury-copper structure, and the release of copper ions to the water. The copper can then be removed from the water using an ion exchanger (Huttenloch et al., 2003).

CHEMICAL PRECIPITATION

RGM can be removed from groundwater by adding precipitating agents that cause the new mercury compound to become insoluble and precipitate out of the solution. Sulfide is a good precipitator of mercury, and is the BACT for treating wastewater streams. The solid particles of mercury sulfide can be separated out by physical means such as gravity settling or filtration.

CARBON ADSORPTION

Carbon adsorption uses granular activated carbon to absorb the mercury. Water is passed through carbon filters where the mercury is pulled out of the water to form a film on the surface of the carbon molecules. When the filters are saturated they are replaced or regenerated. Granular activated carbon must either be disposed of as a waste or regenerated. Regeneration by chemical processes results in a mercury rich solution, which must then be disposed. Thermal regeneration results in mercury enriched vapors.

Other types of adsorption that work on the same principles can use bicarbonate-treated peanut hull carbon, modified *Hardwickia binata* bark, coal fly ash, and the Forager sponge. Bicarbonate-treated peanut hull carbon has been reported, from a bench-scale study, to be seven times more effective at removing mercury than granular activated carbon, due to it's higher porosity. Modified *Hardwickia binata* bark and coal fly ash remove mercury from water streams, but it is not as effective as carbon.

ION EXCHANGE

Ion exchange uses resins containing the iminodiacetic acid group, which will break bonds with former constituents and instead bond with RGM. Mercury has been removed from groundwater using a point of entry treatment at a private water supply well. It is a more common technique for treating the wastewater discharge from industries containing mercury in their wastewater.

7.3 SOILS

Treatment of soils contaminated with mercury generally requires the removal and processing of those soils. Most methods of remediation that remove mercury from soil require it to be excavated first, and sometimes two methods must be used in series to accomplish the best results. An alternative treatment is *in situ* chemical desorption, which separates the mercury first, then removes it. Stabilization, however, does not require removal, containing the contamination in the soil rather than removing it. The following are methods for removal of mercury in soils:

ACID LEACHING

Sometimes called soil leaching, acid leaching is an *ex situ* method. The soil is exposed to a strong acid (e.g. sulfuric or hydrochloric acid), to solubilize the mercury. The leachate is then processed through activated carbon filters to remove the mercury. The soil is washed and left to dry and wash water is run through the same filters to remove remaining heavy metals. Depending on the concentration of mercury in the soil, it may be necessary to repeat the process with the same batch of soil. A typical cycle for this process can take from half an hour to an hour, and commercial operations have reported rates of up to 8 tons per hour. The process, however, does create several waste products, including wastewater, leaching solution, activated carbon, and the extracted mercury. Some of these waste products may require specialized disposal, depending on the concentration of contaminants they inherit.

AMALGAMATION

Amalgamation is the creation of a metal alloy. It is used to combine mercury with another metal (e.g. copper or iron), to create an amalgam, a semi-liquid physical and chemical blend of the different base materials, to produce a non-hazardous material in leachable concentrations. Amalgamation is preformed off site, and is intended for small concentrations of mercury. Hg(0) that is contaminated with radioactive materials is required to be amalgamated by federal regulations.

SOIL WASHING

Soil washing does not remediate the contaminated soil. Instead it separates the larger particles from the smaller silt and clay, which are more likely to attract the sand and gravel particles to which mercury adsorbs. This smaller amount of material can then be put through another process of remediation. Soil washing involves running wash water, which could contain cultured bacteria or detergent, over the soils and sifting the smaller particles out. Then the soils are rinsed with water. This wastewater stream, as well as the wash water, could require treatment before it can be discharged. If the larger particles, left from the process, test below contamination levels they can be returned to the ground as backfill, and a smaller amount of contaminated soil can go on to other remediation techniques. One of the

benefits of this method is that it can occur on-site or off-site, with some facilities able to process 25 tons per hour (Patterson, 1997).

RETORTING

For retort the contaminated material must be crushed and shredded to a uniform size. The actual process of retorting can be performed on or off-site and currently has a process output of 3 to 12 tons per day depending on the material and the equipment (Boyce and Almskog, 1999). The process involves heating the materials to 500 to 1000 degrees Fahrenheit for 4 to 6 hours. This vaporizes the mercury, which is collected under vacuum and condensed as a liquid. The vapor is treated with granular carbon filters or scrubbers and cooling water can assist the condensing. Waste products produced include the cooling water and the filters.

STABILIZATION

Stabilization does not remove the mercury from the contaminated material, but binds it physically or chemically to prevent it from migrating. It is a feasible option for non-wastewaters containing less than 260 mg/kg (ppm) total mercury. The process involves combining the contaminated medium with a stabilizing agent, such as sulfur, fly ash, pozzolan, Portland cement, or kiln dust. Processing rates can be up to 40 tons per day, and there are little or no secondary waste streams.

CONTAINMENT

While containment is not a remediation technique it does prevent exacerbation. Vertical barriers, placed around the contaminated area can prevent migration, and a horizontal cover, placed above the contaminated soil can prevent further exposure. The cap prevents both direct human or wildlife contact as well penetration by surface water. The cap also serves to prevent the volatilization of the contaminant to the air.

ELECTROKINETIC

A low density current passed between electrodes in the soil turns the mercury into a charged species. The charged mercury can then be induced to travel by interaction with an electric field gradient. Once at the electrode, the contaminants can be removed by electroplating, pumping, or precipitation. This method works best in fine grained highly permeable soils. The presence of groundwater facilitates the current between the electrodes.

***IN SITU* THERMAL DESORPTION**

In situ thermal desorption remediates soil by raising the temperature of the area to be treated and using vacuum wells to remove the contaminants. Heat is applied by electrical resistors and then passed through the soil by thermal conduction, raising the temperature of the soil to 600 degrees Celsius. Vacuum can then be used to collect the volatized mercury (Kunkel, et al., 2006).

The system is expensive, and would only be practical in areas where wells can be installed to the necessary depth for the insertion of the resistance heaters. If the section to be remediated is below the water table then water recharge may be necessary.

In laboratory tests, 15 g of mercury were injected into a sand column. The column contained no water and a low organic content. The *in situ* thermal desorption system was able to collect 14.975 g of mercury in about 12 hours. The system required a temperature of about 250 degrees Celsius. However, the presence of groundwater in the soil would raise the temperature required to withdraw the mercury.

7.4 MERCURY REMOVAL AT MUNICIPAL WASTEWATER TREATMENT PLANTS (WWTPS)

There is no treatment method that can completely remove mercury from wastewater. Mercury control technology transfers the mercury from wastewater to sludge, ash, or into the atmosphere. Balogh and Liang (1995) conducted a nine week sampling and analysis program at a large municipal WWTP to characterize the fate of mercury entering the facility. Mercury removal from the wastewater stream in primary treatment averaged 79%, and the average mercury removal across the entire plant was approximately 96%. Nearly all of the mercury removed from the wastewater stream was emitted to the atmosphere via the facilities sludge incinerator. The EPA Capsule Report "*Aqueous Mercury Treatment*" describes established technologies and identifies methods for treating aqueous mercury (EPA, 1997d). These technologies include precipitation and adsorption processes, ion exchange treatment, chemical reduction, and membrane separation. Co-precipitation and ion exchange achieved the lowest effluent mercury concentrations for many waste streams, ranging from 0.5 to 5.0 µg/L. The effectiveness of treatment provided by each type of technology depends on the chemical nature and initial concentration of mercury as well as the presence of other constituents in the wastewater that may interfere with the process.

The "Mesabi Nugget Mercury Filter" (patent pending) is an experimental treatment process which utilizes taconite pellets to remove mercury from wastewater. The developer has documented the "filter's" ability to attain the Michigan WQS of 1.3 ng/L in a bench scale test with the Western Lake Superior Sanitary District (Tuominen, 2006). One of the recommendations proposed in this report is to encourage research on control technology for removal of low-level mercury from municipal or industrial wastewater, such as the Mesabi Nugget Mercury Filter. P2 strategies focusing on removing mercury from the influent stream remain, in most cases, the most economical methodology for removing mercury from WWTPs. See **Chapter 5.2** for P2 efforts in Michigan.

7.5 DENTAL AMALGAM SEPARATORS

An amalgam separator is equipment designed to remove waste amalgam contained in rinse or wastewater from chair-side water collection and other discharge systems. Even common activities such as rinsing chair-side traps, screens, vacuum pump filters or other amalgam collection devices generate mercury waste; therefore, these activities must be done over drains or sinks that are equipped with an amalgam separator.

Sedimentation-based separator units have baffles or tanks that reduce the speed of the wastewater flow, allowing amalgam particles to settle out of the waste. Filtration units also can remove amalgam particles, in addition to colloidal particles and dissolved mercury, depending on the types of filters used. Centrifuge-based separator units spin wastewater, relying on centrifugal force to draw the amalgam particles to the sides of the unit. Ion-exchange systems take advantage of the tendencies of certain chemicals to bind with dissolved mercury in the dental water stream, causing the minute amalgam particles to separate from the solution and rest at the bottom of the separator. Amalgam separators that use ion exchange are well-suited for use in municipalities that have specific concentration limits on mercury-containing discharge into the waste stream, because they can remove very small amalgam and cationic mercury particles more readily than can sedimentation models. Separators that use ion exchange also do not rely totally on physical settling of particles, which is better for an in-line system handling peak flows (McManus, 2003).

Many models use sedimentation, which collects amalgam particles that settle out from the wastewater. Because of the high specific gravity of amalgam, sedimentation removes a considerable amount of amalgam in wastewater. Simple sedimentation can remove about

90% of amalgam particles from a water sample in a matter of several hours (McManus, 2003). Some amalgam separators use sedimentation followed by filtration and ion exchange, with the aim of removing smaller amalgam particles not removed by sedimentation as well as dissolved mercury particles (for example, cationic mercury).

Designs are incorporated into some amalgam separators that allow for longer sedimentation time. Draining of the wastewater collected in the amalgam separator can be achieved by suction, electrical pumps or gravity drainage. A laboratory evaluation of 12 commercially available amalgam separators that use various separation techniques documented more than 95% efficiency for amalgam removal, a performance level that exceeds the ISO's requirement for this equipment (McManus, 2003).

As with the purchase of any equipment, cost clearly is a key issue when choosing an amalgam separator. True side-by-side comparisons of system costs are difficult, because numerous pricing and leasing programs exist. For example, some vendors offer purchase plans for just the system, while others provide lease-based systems that include replacement of filter cartridges or ion-exchange cartridges and recycling of amalgam waste. A typical separator costs approximately $1,000 with additional fees for installation. Annual operation and maintenance costs range $100 to $150 per year. The average life expectancy of an amalgam separator is approximately five years (McManus, 2003).

In summary, development of state-of-the art mercury pollution control is a dynamic and rapidly evolving technology. Significant progress on mercury controls has been made and is currently being used in Michigan. Regardless of what type of control is implemented, permanent capture is needed to assure that the mercury is not being transferred from one environmental media to another.

7.6 EMERGING TECHNOLOGIES

NANOTECHNOLOGY

As described in the *Final EPA White Paper on Nanotechnology* (EPA, 2007b), EPA states:

> "Self-assembled monolayers on mesoporous supports (SAMMS) are nanoporous ceramic materials that have been developed to remove mercury or radionuclides from wastewater (Mattigod, 2003). Nanomaterials have also been studied for their ability to remove metal contaminants from air. Silica-titania nanocomposites can be used for Hg(0) removal from vapors such as those coming from combustion sources, with silica serving to enhance adsorption and titania to photocatalytically oxidize Hg(0) to the less volatile mercuric oxide (Pitoniak, 2005)."

Also, nanotechnology substitutes could replace certain mercury-containing products...

> "Nanotechnology is also used for Organic Light Emitting Diodes (OLEDs). OLEDs are a display technology substitute for Cathode Ray Tubes, which contain lead. OLEDs also do not require mercury, which is used in conventional Flat Panel Displays (Frazer, 2003). OLED displays have additional benefits of reduced energy use and overall material use through the lifecycle (Wang and Masciangioli, 2003)."

8. EVALUATION ON HOW TO IMPROVE EXISTING PROGRAMS WITH CROSS-DIVISIONAL COOPERATION

Early in the Strategy development process, senior department executives challenged the MSWG to develop recommendations on how to improve mercury multi-media program coordination within the MDEQ. The strategy development process began with each division/bureau representative giving the MSWG a slide presentation on mercury programs and issues facing each respective division. While the team began meeting regularly at bi-weekly intervals, a number of communication issues came to the workgroup's attention:

COMMUNICATION GAPS

In the future, the MSWG recommends that staff from each MDEQ Division/Bureau continue meeting regularly on a monthly basis, at a minimum, to discuss and coordinate mercury issues facing the Department. Important issues could then be brought to the attention of mid-level managers in each division as necessary, to promote a continuous flow of information with respect to emerging or controversial mercury issues. A continuing dialog should also enable the Department to be more proactive, rather than reactive. More lead time would be available for input on such things as rules development, bill analyses, spill response, technology transfer, permit conditions, TMDL development and other relevant mercury multi-media issues.

Throughout the MSWG development process, several outside experts from the MDCH and MDEQ gave presentations to inform the group of emerging issues within their respective areas and it is recommended that this forum be continued. Conversely the MSWG could conduct briefings by meeting periodically with district staff, multi-media coordinators and the senior management team as deemed necessary.

NEED TO IDENTIFY EXPERTISE WITHIN THE MDEQ

One exercise that proved useful for the MSWG was updating the Michigan portion of the QSC's Compendium of States' Mercury Activities (see **Appendix U**).[178] This is a Michigan specific chapter, a kind of a "Who Does What" mercury tool that will serve useful to MDEQ staff. It is particularly important that when MDEQ receives inquiries about mercury-related issues, that they are able to quickly refer the caller or inquiry to the proper person be it; fish tissue testing information, mercury auto switches, P2 programs, mercury spill reporting, recycling/disposal opportunities, monitoring research, air permit conditions or general mercury questions.

Because of the various needs in each MDEQ Division/Bureau, it is recommended that there is at least one staff from each Division/Bureau that is dedicated to mercury activities.

NEED FOR A FORUM TO SHARE EXPERTISE WITHIN THE MDEQ

The MSWG created an Intranet site for sharing information and reports. Material posted there is now available to all MDEQ staff and management so that anyone within the Department could familiarize themselves with MSWG activities. The MSWG also subscribes as a group to the National Mercury-Policy List Serve and created an internal MSWG List Serve to help keep each other up to speed on mercury issues of interest. As such changes have proven extremely beneficial; it is recommended that these practices continue throughout the implementation phase of the mercury strategy and beyond.

In addition to drafting the *MDEQ Mercury Strategy Staff Report,* the MSWG members were able to achieve numerous accomplishments (see **Appendix V**). These activities were either accomplished by a MSWG member, or a MSWG member contributed to the efforts. The time frame included was from when the MSWG was convened in January 2006 through when the final MSWG report was finalized in January 2008.

[178] Michigan's compiled mercury activities that were in response to the QSC's survey are available at http://www.deq.state.mi.us/documents/deq-ess-ECOSMercurySurvey1-10-05final.pdf.

9. RECOMMENDATIONS

The following is the MSWG's recommended list of 67 action steps for the MDEQ to achieve the goal of eliminating anthropogenic mercury use and releases. These recommendations have been divided into three specific goals that should be implemented in order to achieve success.

- Goal 1 is to develop a comprehensive baseline to track and measure all mercury releases to all Michigan media.
- Goal 2 includes various approaches and activities that will contribute to eliminating anthropogenic mercury use and releases in Michigan in order to meet designated water uses in the state, including fish consumption.
- Goal 3 is to create a mechanism to measure progress toward the goal of elimination of anthropogenic mercury use and releases to Michigan's environment, using defined baseline data.

(**NOTE: THE BOLDED AND CAPPED ITEMS SHOWN IN THE FOLLOWING LIST FOR ALL OF THE MSWG'S RECOMMENDATIONS ARE THOSE THAT WOULD REQUIRE ADDITIONAL RESOURCES TO SUCCESSFULLY IMPLEMENT. ALSO, THE NUMBERED RECOMMENDATIONS UNDER EACH CHAPTER ARE PRESENTED IN ORDER OF IMPORTANCE.**)

GOAL 1 – BASELINE DEVELOPMENT: IDENTIFY ALL ANTHROPOGENIC MERCURY USE AND RELEASES IN MICHIGAN; DEVELOP A DEFINED BASELINE TO MEASURE MERCURY RELEASES TO ALL MEDIA INCLUDING AIR, WATER, AND LAND; AND UTILIZE THIS BASELINE TO MEASURE REDUCTION PROGRESS.[179]

ACTION STEPS:

1.1) Complete an updated speciated air toxics emissions inventory. The first speciated inventory was done for 2002, but subsequent speciated emission inventories should be completed every three years, at a minimum to evaluate progress. Recommend to the U.S. Environmental Protection Agency (EPA), the development of improved emission factors for certain source categories that emit mercury. (*See* ***Chapter 2.1.2***, ***Table 2-1*** *and* ***Appendix G***)

1.2) **INVENTORY RELEASES OF MERCURY TO WATERS OF THE STATE AND MERCURY THAT ENTERS THE WASTE STREAM UTILIZING THE MERCURY FLOW MODEL THAT WAS USED TO INVENTORY MERCURY AIR RELEASES. THE MERCURY FLOW MODEL WAS UTILIZED FOR CALCULATED RELEASES TO THE AIR; HOWEVER, STAFF RESOURCES DID NOT ALLOW ESTIMATED RELEASES OF MERCURY TO THE WATER AND WASTE STREAM.** (*See* ***Chapter 2.1.2***)

1.3) **INVENTORY RELEASES FROM WASTEWATER TREATMENT PLANTS (WWTPS), INDUSTRY, AND OTHER SOURCES OF MERCURY RELEASES TO WATER (BOTH SURFACE WATER AND GROUNDWATER). (THIS INCLUDES, BUT IS NOT LIMITED TO, GETTING A BETTER ESTIMATE ON MERCURY RELEASED FROM STAMP SANDS IN MICHIGAN'S UPPER PENINSULA, COLLECTING DATA ON THE MERCURY CONTENT IN SEPTAGE, AND REQUIRE REPORTING OF PART 201 FACILITY STATUS THAT INCLUDES DISCLOSURE OF MERCURY RELEASES TO GROUNDWATER AND/OR SURFACE WATER.)** (*See* ***Chapter 2.3***)

1.4) **IDENTIFY SITES OF LEGACY MERCURY CONTAMINATION. DEVELOP UNIFORM EVALUATION REQUIREMENTS TO CONFIRM/ASSESS POTENTIAL MERCURY RELEASES AT SITES OF ENVIRONMENTAL CONTAMINATION. (COLLECT DATA FROM SITES OF ENVIRONMENTAL CONTAMINATION TO ESTABLISH BASELINE DETERMINATION).** (*See* ***Chapter 2.3***)

1.5) **DEVELOP A MECHANISM TO CONFIRM THAT PAST MERCURY-CONTAINING PRODUCT MANUFACTURERS ARE NO LONGER USING MERCURY AND THAT NO LEGACY MERCURY SITUATIONS EXIST AT SUCH SITES**. (*See* ***Chapter 2.3***)

[179] A defined baseline will be developed per source category dependent upon available data and will be part of the implementation plan.

1.6) Continue to track statewide variances for mercury discharges to surface waters. (*See **Chapter 3.2.1***)

1.7) **WORK WITH MICHIGAN DEPARTMENT OF COMMUNITY HEALTH (MDCH) STAFF TO IDENTIFY AND QUANTIFY INDOOR MERCURY SPILLS REPORTED TO THE MDCH, MICHIGAN'S HAZARDOUS SUBSTANCES EMERGENCY EVENTS SURVEILLANCE (MI-HSEES), MDEQ'S POLLUTION EMERGENCY ALERTING SYSTEM (PEAS), POISON CONTROL CENTERS, NATIONAL RESPONSE CENTER (NRC), AND MDEQ STAFF. JOINTLY DETERMINE COMMON CAUSES OF RECENT (SMALL QUANTITY) INDOOR SPILLS OF MERCURY AT RESIDENTIAL AND COMMERCIAL FACILITIES. UTILIZE THIS INFORMATION IN BASELINE DETERMINATION AS ONE SOURCE OF DATA THAT CAN HELP ASSIST IN MEASURING PROGRESS. RECOMMEND HOSTING A MEETING WITH ALL PARTIES TO DISCUSS IMPROVED COMMUNICATION AND COLLABORATION ON MERCURY SPILL DATA TRACKING.** (*See **Chapter 2.6***)

1.8) **DEVELOP A PROTOCOL FOR MASS BALANCE CALCULATIONS FOR ESTIMATING RELEASES OF MERCURY FROM SOURCES. THIS HAS BEEN CONDUCTED FOR THE TACONITE INDUSTRY IN MINNESOTA AND COULD BE UTILIZED IN MICHIGAN FOR OTHER SOURCE SECTORS.** (*See **Appendix G***).

1.9) Summarize hazardous waste manifests with special focus to identify and track mercury-containing waste transferred in and out of Michigan annually. (*See **Chapter 2.4.1***)

1.10) Compile mercury use and release information generated from the Toxics Release Inventory and Annual Wastewater Report and compare the data to the current baseline to address any inaccuracies. (*See **Table ES-1, Table 2.8***)

GOAL 2 - ELIMINATION/REDUCTION ACTIVITIES: ELIMINATE ANTHROPOGENIC MERCURY USE AND RELEASES TO THE ENVIRONMENT IN MICHIGAN THROUGH VARIOUS APPROACHES IN ORDER TO MEET DESIGNATED WATER USES IN THE STATE, INCLUDING FISH CONSUMPTION.

To assist in measuring progress toward the final goal of elimination of anthropogenic mercury use and releases, the MSWG developed the following two interim goals after reviewing current reduction activities and recommended reductions from specific sectors in Michigan, as well as the Lake Superior Bi-National Strategy and the Northeast Governors and Eastern Canadian Premiers' Mercury Action Plan [further information is available in **Chapter 5.4**].):

- **REDUCE ANTHROPOGENIC MERCURY USE AND RELEASES IN THE STATE BY 50% BY 2010;**
- **REDUCE ANTHROPOGENIC MERCURY USE AND RELEASES IN THE STATE BY 90% BY 2015.**

THE MSWG RECOGNIZES THAT FOR THIS STRATEGY IMPLEMENTATION TO SUCCEED, THE MDEQ NEEDS TO ENSURE THAT THE MERCURY STRATEGY IS A PRIORITY AND THAT SUFFICIENT RESOURCES ARE DEDICATED TO THIS IMPORTANT MULTI-MEDIA CONCERN. RESOURCES SHOULD BE DEDICATED TO FULLY FUND THE NECESSARY STAFF IN EACH DIVISION AND/OR BUREAU WITH RESPONSIBILITIES TO TRACK, IMPLEMENT, AND EVALUATE PROGRESS UNDER MERCURY POLLUTANT MINIMIZATION PROGRAMS, MERCURY EDUCATION AND OUTREACH PROGRAMS, AS WELL AS MERCURY MONITORING AND EVALUATION PROGRAMS.

The Goal 2 Elimination/Reduction Activities have been broken down into four separate categories with each category containing its own action steps. These following categories are: Regulatory Approaches, Collaboration/Partnerships, Education/Outreach, and Monitoring/Research.

REGULATORY APPROACHES

ACTION STEPS:

RA-2.1) For new or modified air sources, develop a mercury impacts assessment guidance document that includes a recommendation for *de minimus* emission and/or deposition quantities allowed (clarification of NREPA Part 55, R 336.1228). Clarify how NREPA Part 55, R 336.1290 (permit to install exemptions) addresses mercury emissions.

These *de minimus* amounts would not expect to cause or significantly contribute to exceedances of any health protective standards. If the *de minimus* amount is exceeded, this guidance document should also identify when a multipathway risk assessment is required and when a less vigorous screening evaluation may be sufficient, and recommend an approach for this assessment. (*See* ***Chapter 3.1.2***)

RA-2.2) **DEVELOP GENERAL AND/OR SOURCE SPECIFIC AIR QUALITY RULES FOR ATMOSPHERIC MERCURY RELEASES THAT APPLY TO NEW, MODIFIED, AND EXISTING SOURCES. THESE RULES SHOULD UTILIZE THE APPLICABLE RECOMMENDATIONS CONTAINED WITHIN THE MERCURY IMPACTS ASSESSMENT GUIDANCE DOCUMENT DESCRIBED IN RA-2.1. THE SOURCE CATEGORIES SHALL INCLUDE, BUT ARE NOT LIMITED TO:**

- **COAL-FIRED EGUS, REQUIRING 90% REDUCTION OF MERCURY BY 2015 OR AN ALTERNATIVE EMISSION LIMIT.** These rules are currently in development. (*See* ***Chapter 2.1.2***)
- **PORTLAND CEMENT PLANTS.**
- **SEWAGE SLUDGE INCINERATORS.**
- **MANUFACTURING FACILITIES THAT USE AND RELEASE MERCURY.**

Examples from other states can be followed. *(See* ***Chapter 3.1.2****)*

RA-2.3) Support the adoption of legislation that will phase out the sale of mercury-containing products in instances where viable mercury-free products exist, and require labeling for any remaining mercury-containing products based on the model legislation developed by NEWMOA. (*See* ***Chapter 3.7.1***)

RA-2.4) **ALL AIR EMISSION SOURCES EMITTING MERCURY SHALL REPORT THEIR EMISSIONS TO THE MDEQ EACH YEAR. A REPORTING THRESHOLD WILL BE ESTABLISHED AND A FEE REQUIRED FOR THE FACILITIES THAT EMIT OVER A CERTAIN AMOUNT OF MERCURY AS DETERMINED BY A STAKEHOLDER WORKGROUP. THIS REPORTING THRESHOLD SHALL BE NO GREATER THAN 5 POUNDS PER YEAR.** (See ***Table 2-1***)

RA-2.5) **DEVELOP AIR QUALITY RULES THAT REQUIRE STACK TESTING FOR MERCURY FOR ALL NEW OR MODIFIED MERCURY-EMITTING SOURCES. FOR CERTAIN SOURCES, REQUIRE SPECIATED STACK TESTING OR CONTINUOUS EMISSION MONITORS FOR ALL NEW OR MODIFIED MERCURY-EMITTING SOURCES.** (*See* ***Chapter 6.1.5***)

RA-2.6) **DEVELOP RULES FOR REMOVAL OF MERCURY-ADDED PRODUCTS FROM BUILDINGS PRIOR TO BEING DEMOLISHED.** (*See* ***Chapter 3.1.2***)

RA-2.7) **REVIEW AND EVALUATE VARIOUS MERCURY TOTAL MAXIMUM DAILY LOAD (TMDL) APPROACHES IN THE NATION AND DEVELOP MERCURY TMDLS IN MICHIGAN FOR IMPAIRED WATERBODIES BY 2011, UNLESS THE 5M APPROACH IS UTILIZED. IF THE 5M APPROACH IS SELECTED, SIGNIFICANT RESOURCES MUST BE DEDICATED FOR IMPLEMENTATION OF THIS STRATEGY.** (*See* ***Chapter 3.2.1***)

RA-2.8) **ASSURE COMPLIANCE/ENFORCEMENT OF CLEAN-UP OBLIGATIONS WITH EXISTING (AT THE FINAL DATE OF THIS REPORT) STANDARDS (SUCH AS DRINKING WATER AND DIRECT CONTACT STANDARDS) AT CURRENT LEGACY SITES.** (*See* ***Chapters 2.3*** *and* ***3.3***)

RA-2.9) **SUPPORT DEVELOPMENT OF A COMPREHENSIVE COLLECTION NETWORK IN MICHIGAN THAT ACCEPTS MERCURY-ADDED PRODUCTS, SUCH AS THERMOMETERS, BAROMETERS, THERMOSTATS, INCLUDING FLUORESCENT LIGHTS, ETC. PRIORITY SHOULD BE GIVEN TO AREAS WHERE MUNICIPAL WASTE IS INCINERATED. ONCE THIS COLLECTION NETWORK IS ESTABLISHED, SUPPORT THE ADOPTION OF FURTHER LEGISLATION THAT BANS DISPOSAL OF THESE MERCURY-ADDED PRODUCTS IN THE MUNICIPAL WASTE STREAMS.** (*See* ***Chapter 3.7****)* (*This recommendation is linked to* ***Action Step: E/O-2.1***). If Michigan adopts an energy efficiency program as recommended in the 21st Century Energy Plan, part of that program should be used to support collection of mercury-containing items. (*See* ***Chapter 5.1***).

RA-2.10) **RECOMMEND TO MUNICIPALITIES WITH MERCURY MINIMIZATION PROGRAMS THAT THEY REQUIRE CERTIFIED DENTAL AMALGAM SEPARATORS OR EQUIVALENT TECHNOLGY AS APPROVED BY THE MDEQ BY 2009. FOR DENTAL OFFICES USING SEPTIC SYSTEMS, REQUIRE THE USE OF DEDICATED ISOLATED HOLDING TANKS FOR DENTAL MERCURY AMALGAM WASTE BY 2009. ADDITIONALLY, DENTAL PRACTICES SHOULD BE REQUIRED TO USE "BEST MANAGEMENT PRACTICES" FOR DENTAL AMALGAM MANAGEMENT WHICH INCLUDES PROPER OPERATION AND MAINTENANCE OF THIS EQUIPMENT, AS WELL AS PROVISIONS REQUIRING WASTE MANIFEST TRACKING OF DENTAL AMALGAM WASTE.** (*See **Chapters 4.4.2** and **5.2***)

RA-2.11) **REQUIRE ALL DENTAL PRACTICES IN MICHIGAN THAT PLACE OR REMOVE MERCURY AMALGAM FILLINGS TO INSTALL DENTAL AMALGAM SEPARATORS OR EQUIVALENT TECHNOLOGY AS APPROVED BY THE MDEQ BY 2011. ADDITIONALLY, DENTAL PRACTICES SHOULD BE REQUIRED TO USE "BEST MANAGEMENT PRACTICES" FOR DENTAL AMALGAM MANAGEMENT WHICH INCLUDES PROPER OPERATION AND MAINTENANCE OF THIS EQUIPMENT, AS WELL AS PROVISIONS REQUIRING WASTE MANIFEST TRACKING OF DENTAL AMALGAM WASTE.** (*See **Chapters 3.7, 4.4.2,** and **7.5)***

RA-2.12) The MDEQ will continue to encourage removal of mercury switches from end-of-life vehicles through various measures, including participation in the National Mercury Vehicle Switch Recovery Program and incorporating mandatory switch removal requirements in air permits issued by the AQD for new or expanded steel manufacturing facilities and shredders. The AQD will continue to monitor compliance with the mercury switch removal requirement in the five existing air permits for shredders. (*See **Chapter 7.1.8***)

RA-2.13) By September 1, 2008, the MDEQ's Water Bureau (WB) will write a letter to all auto recycling facilities covered by a Storm Water Discharge Permit, including salvage yards and shredders, strongly encouraging them to participate in the National Mercury Vehicle Switch Recovery Program. Notice of this request should also be communicated to the Automotive Recyclers of Michigan and the Michigan Chapter of the Institute of Scrap Recycling Industries. (*See **Chapter 4.2.2** and **Table 2-10***)

RA-2.14) **THE MDEQ'S WB SHOULD DEVELOP A SECTOR SPECIFIC STORMWATER PERMIT FOR AUTO SALVAGE YARDS. INCLUDED IN THE PERMIT SHOULD BE A PROVISION REQUIRING THE REMOVAL OF MERCURY SWITCHES. BEFORE THE DEVELOPMENT AND ISSUANCE OF THIS PERMIT, THE WB NEEDS TO CONDUCT APPROPRIATE STORMWATER MONITORING AT REPRESENTATIVE FACILITIES.** (*See **Chapter 4.2.2***)

RA-2.15) Develop a general air permit that controls mercury released from fluorescent bulb drum crushers. (*See **Chapter 6.1.1** and **Appendix S***)

RA-2.16) Utilize enforcement activities such as supplemental environmental projects (SEPs) to help implement MSWG recommendations including activities associated with the reduction, disposal, and/or recycling of mercury. Use the summary of successful SEPs utilized in Michigan to identify, monitor, or reduce mercury use and release in Michigan. (*See **Chapter 4.2.10***). The MSWG should develop a list of recommended SEPs for future mercury project funding consideration.

RA-2.17) Develop a moratorium on new medical and solid waste incinerators. (*See **Chapter 3.1.2***)

COLLABORATION/PARTNERSHIPS

ACTION STEPS:

C/P-2.1) Continue to have the Michigan MSWG coordinate multi-media policies/regulations/permits and educational material as it relates to mercury. Include contact information on the MDEQ website. (*See **Chapter 8)***

C/P-2.2) Collaborate with the other seven Great Lakes States to develop a regional mercury emission reduction initiative similar to the Great Lakes *Mercury in Products Phase-Down Strategy* (*see* ***Chapters 4.3 and 5.4.4***) and the New England Governor/Eastern Canadian Premiers Mercury Action Plan. (*See* ***Chapter 5.4.2***)

C/P-2.3) **INVESTIGATE AND EXPLORE THE DEVELOPMENT OF A MECHANISM TO ENSURE THAT MERCURY COLLECTED OR RECOVERED IN MICHIGAN IS USED ONLY FOR ESSENTIAL USES. EXPLORE THE CURRENT BARRIERS REGARDING EXPORTATION OF NONESSENTIAL MERCURY USES TO OTHER STATES OR COUNTRIES.** (*See* ***Chapter 2.5***)

C/P-2.4) **CONTINUE PARTICIPATION AND COLLABORATION WITH QSC EFFORTS, THE EPA'S REGION 5 MERCURY WORKGROUP, THE REGIONAL MERCURY MONITORING WORKGROUP FACILITATED BY THE GREAT LAKES COMMISSION, EPA/ENVIRONMENT CANADA'S BI-NATIONAL TOXICS STRATEGY, THE ONTARIO MINISTRY OF THE ENVIRONMENT ON THE RENEWED EFFORT TO REDUCE MERCURY, EPA'S MERCURY ROADMAP, EPA/MDEQ CHILDREN'S HEALTH INITIATIVES, THE GREAT LAKES MERCURY IN PRODUCTS PHASE-DOWN STRATEGY WORKGROUP, THE LAKE-WIDE AREA MANAGEMENT PLANS REQUIRED UNDER THE GREAT LAKES WATER QUALITY AGREEMENT, ETC., TO SHARE RESOURCES AND KNOWLEDGE IN WORKING FOR COMMON REDUCTION GOALS.** (*See* ***Chapter 5.4***)

C/P-2.5) Continue ensuring the successful transition of the Michigan Mercury Switch Sweep Program into the National Vehicle Mercury Switch Recovery Program for mercury-containing auto switches, and report annually on its success. (*See* ***Chapter 4.2.2***)

C/P-2.6) Recommend mercury reductions in biosolids by focusing further efforts on reducing wastewater inputs with local communities, notably from the dental and health care sectors. (*See* ***Chapters 4.4.1*** *and* ***4.4.2***).

C/P-2.7) **CONTINUE TO WORK WITH VARIOUS STAKEHOLDERS ENSURING IMPLEMENTATION OF THE GOVERNOR'S 21ST CENTURY ENERGY PLAN, INCLUDING THE ADOPTION OF A RENEWABLE PORTFOLIO STANDARD TO INCREASE THE USE OF RENEWABLE RESOURCES AND IMPROVE CONSERVATION ENERGY EFFICIENCY PROGRAMS, THEREBY DECREASING MICHIGAN'S RELIANCE ON FOSSIL FUELS. INCENTIVES SHOULD ALSO BE PROVIDED FOR CLEAN ENERGY.** (*See* ***Chapters 5.1*** *and* ***7.1.6***)

C/P-2.8) **CONTINUE PARTICIPATION IN THE SCHOOLS CHEMICAL CLEANOUT CAMPAIGN FOR MERCURY.** (*See* ***Chapter 4.2.8***)**.**

C/P-2.9) Continue to promote and support the "Catch the Fever" Michigan Mercury Thermometer Exchange program, partnering with the Michigan Association for Local Public Health (possibly through enhanced SEPs). (*See* ***Chapter 4.2.5***)

C/P-2.10) **SUPPORT THE QUICKSILVER CAUCUS RESOLUTION ON THE SEQUESTRATION OF ELEMENTAL MERCURY [HG(0)]. DEDICATE RESOURCES AND SUPPORT MEASURES THAT RESTRICT THE EXPORTATION OF HG(0) TO DEVELOPING COUNTRIES.** (*See* ***Chapter 5.3***).

C/P-2.11) **QUANTIFY COLLECTION OF HG(0) WITHIN THE STATE AND DETERMINE ITS FATE.** (*See* ***Chapter 4.2.7*** *and* ***Table 4-1***)

C/P-2.12) **JOIN THE INTERSTATE MERCURY EDUCATION AND REDUCTION CLEARINGHOUSE TO SUPPORT STATE EFFORTS THAT PHASE OUT THE SALE OF CERTAIN MERCURY PRODUCTS AND REQUIRE ALL OTHER PRODUCTS TO BE LABELED.** (*See* ***Chapters 3.7.2*** *and* ***4.4.2***)

C/P-2.13) Encourage manufacturers to choose mercury-free components when developing their products regardless of how small the amount of mercury (i.e., mercury in batteries, fluorescent lights, switches, etc.). (*See* ***Chapter 2.5***).

C/P-2.14) **ENSURE THOSE INVOLVED IN ADMINISTERING THE NEW "GREEN CHEMISTRY" INITIATIVE (ESTABLISHED BY GOVERNOR'S EXECUTIVE DIRECTIVE) INCORPORATE MEASURES CONSISTENT WITH THE GOALS OF THIS STRATEGY TO ELIMINATE MERCURY USE AND RELEASES.** (*See* ***Chapter 4.2****,* ***Appendix P***).

C/P-2.15) Encourage mercury reduction commitments through MDEQ's voluntary P2 programs and ensure that mercury P2 opportunities are incorporated into the Clean Corporate Citizen, Michigan Business Pollution Prevention Partnership, Environmental Management Systems, the Michigan Turfgrass Program, the Clean Marina's Initiative, and the Pulp and Paper P2 Partnership. (*See* ***Chapter 1.4***)

EDUCATION/OUTREACH

ACTION STEPS:

E/O-2.1) **CONDUCT OUTREACH TO MICHIGAN'S CITIZEN'S ABOUT EXISTING MERCURY COLLECTION DROP-OFF OPPORTUNITIES WITHIN THE STATE.** (*See* ***Chapter 4.2.7***)

E/O-2.2) **RECOMMEND TO MDCH TO RESTORE FUNDING FOR UPDATING AND PUBLISHING THE MICHIGAN FISH CONSUMPTION ADVISORY. INFORMATION SHOULD BE INCLUDED ON HEALTH RISKS AND BENEFITS OF FISH CONSUMPTION AS BOTH METHYLMERCURY AND OMEGA-3 FATTY ACID LEVELS IN FISH ARE HIGHLY VARIABLE. EXPAND DISTRIBUTION OF MATERIALS DEVELOPED FOR THE SAGINAW BAY WATERSHED REGARDING FISH CONSUMPTION EDUCATION.** (*See* ***Chapter 1.3***)

E/O-2.3) **ASSIST IN OUTREACH ON MERCURY EXPOSURE RISKS AND REDUCTION ACTIVITIES TARGETING LOCAL OUTREACH TO RURAL AREAS, URBAN CENTERS, AND TRIBES THAT POTENTIALLY COULD BE EXPOSED TO MORE MERCURY THAN THE GENERAL PUBLIC.** (*See* ***Chapter 1.3***).

E/O-2.4) Identify gaps and provide training for MDEQ staff with regard to emerging mercury issues. This training would include relevant information on any new mercury legislation and/or state policies. Technical training should also be developed for emerging and existing control technologies, such as fluorescent bulb crushers, mercury auto switch recovery, and combustion sources. (*See* ***Chapter 8***)

E/O-2.5) **EXPAND EDUCATION/OUTREACH TO THE PUBLIC. THIS INCLUDES DEVELOPING A COMPREHENSIVE MDEQ MERCURY WEB PAGE, UPDATING AND DISTRIBUTING THE SMALL MERCURY SPILLS FACT SHEET, PROMOTING THE INCREASED USE OF ENERGY EFFICIENT LAMPS SUCH AS COMPACT FLUORESCENT LIGHTS (CFL) AND ENCOURAGE THE RECYCLING OF CFLS.** (*See* ***Chapters 2.5*** *and* ***2.6***)

E/O-2.6) As necessary, advocate semi-annual mercury spill response and prevention training for County Health Departments/Fire Departments in collaboration with MDCH. (*See* ***Chapter 2.6.3***)

E/O-2.7) **CONDUCT OUTREACH TO MICHIGAN'S HEATING VENTILATION AND AIR CONDITIONING WHOLESALERS, HOME IMPROVEMENT STORES, AND CONTRACTORS TO INCREASE THE COLLECTION OF MERCURY-CONTAINING THERMOSTATS UTILIZING METHODS SUCH AS THE THERMOSTAT RECYCLING CORPORATION OR OTHER VOLUNTARY INITITATIVES, AND/OR WORKING WITH OTHER LOCAL GOVERNMENTAL AGENCIES.** (*See* ***Chapter 4.4.3***)

E/O-2.8) Work with insurance companies and employee unions to ensure cost coverage for non-mercury dental composites reimbursement that is equal to amalgams. (*See* ***Chapter 4.2.6***)

E/O-2.9) Continue outreach to schools to ensure compliance with Michigan's regulation prohibiting use of Hg(0) and mercury-containing instruments in Michigan's K-12 schools. Post a list of mercury-free schools on MDEQ website. (*See* ***Chapter 4.2.8***)

E/O-2.10) Educate insurance companies on the hazards of mercury in the home and ask them to consider offering incentives such as discounts on premiums for mercury-free homes (emphasis on mercury thermometers and thermostats). (*See* ***Chapter 2.6***)

E/O-2.11) Educate crematories on the hazards of mercury and encourage an environmentally preferred solution to decrease mercury emissions. (*See* ***Chapter 2.1.2***)

E/O-2.12) **WORK TOWARD BUILDING VOLUNTARY PARTNERSHIPS WITH "HOME IMPROVEMENT" STORES FOR EDUCATING CONSUMERS ABOUT MERCURY-FREE PRODUCTS AND TO COLLECT SPENT MERCURY-ADDED PRODUCTS SUCH AS LAMPS AND THERMOSTATS.** (*See **Chapter 4.4.3***)

MONITORING/RESEARCH

ACTION STEPS:

M/R-2.1) **RECOMMEND A COMPREHENSIVE MERCURY STUDY BE CONDUCTED THAT IDENTIFIES THE PROCESSES AND ECOSYSTEM CHARACTERISTICS THAT GOVERN THE MOVEMENT OF MERCURY FROM THE ATMOSPHERE, THROUGH AQUATIC ECOSYSTEMS AND WITHIN THE FOOD CHAIN AND IDENTIFIES SOURCE CONTRIBUTIONS. ALSO PROMOTE THE RECOMMENDATIONS PROVIDED IN THE REPORT BY THE GREAT LAKES STATES MERCURY DEPOSITION MONITORING DISCUSSION GROUP.** (*See **Chapter 6.1.2***).

M/R-2.2) **RECOMMEND A STUDY BE CONDUCTED ON NATIVE MICHIGAN POPULATIONS MOST AT RISK EXAMINING THEIR EXPOSURE AND RISKS TO MEHG VIA FISH CONSUMPTION.** (*See **Chapter 1.3.1***)

M/R-2.3) **MDEQ SHOULD REVIEW THE MERCURY WATER QUALITY STANDARD (WQS) IN COOPERATION WITH EPA AND STAKEHOLDER, IN LIGHT OF NEW SCIENCE TO DETERMINE WHETHER CHANGES TO THE WQS ARE NECESSARY AND FEASIBLE.** (*See **Chapter 3.2.1***)

M/R-2.4) **CONTINUE THE PARTNERSHIP WITH THE UNIVERSITY OF MICHIGAN'S AIR QUALITY LABORATORY TO ASSESS TEMPORAL AND SPATIAL TRENDS OF MERCURY DEPOSITION IN THE STATE AND TO IDENTIFY SOURCE REGIONS WITHIN THE STATE.** (*See **Chapter 6.1.2***).

M/R-2.5) Continue the partnership with Wisconsin and Minnesota for utilizing the mercury monitoring laboratory to assess atmospheric fugitive releases in the tri-state region. (*See **Chapter 6.1.1***)

M/R-2.6) Track MDCH reporting of mercury via surveillance system based on lab reporting requirement for arsenic, mercury, cadmium, and cholinesterase clinical tests. (*See **Chapter 3.6***)

M/R-2.7) Review current water and fish monitoring efforts, revise as necessary, and track spatial and temporal trends. (*See **Chapters 1.3** and **6.2.5***)

M/R-2.8) **ENCOURAGE RESEARCH ON CONTROL TECHNOLOGY FOR REMOVAL OF LOW-LEVEL MERCURY FROM MUNICIPAL OR INDUSTRIAL WASTEWATER, SUCH AS THE MESABI NUGGET MERCURY FILTER (PATENT PENDING).** (*See **Chapter 7.5***)

M/R-2.9) **RE-EVALUATE THE SOIL BACKGROUND MERCURY CRITERIA UNDER PART 201 FOLLOWING A COMPREHENSIVE LITERATURE REVIEW AND DISCUSSION WITH APPROPRIATE EXPERTS; IMPLEMENT ADDITIONAL MONITORING STUDIES AS RESOURCES ALLOW.** (*See **Chapter 1.5, Table 1-4***)

M/R-2.10) **RECOMMEND A PILOT STUDY ON THE BEST AVAILABLE CONTROL TECHNOLOGY TO CONTROL MERCURY EMISSIONS RELEASED FROM PORTLAND CEMENT PLANTS.** (*See **Chapter 2.1.2***)

M/R-2.11) Evaluate the efficacy of the mercury WQS for rivers and connecting channels as compared to lakes. (*See **Chapter 3.2.1***)

GOAL 3 – MEASURING SUCCESS: CREATE A MECHANISM TO MEASURE PROGRESS TOWARD THE GOAL OF ELIMINATING ANTHROPOGENIC MERCURY USE AND RELEASES TO THE ENVIRONMENT IN MICHIGAN, USING DEFINED BASELINE DATA.

In order to evaluate the success of achieving the mercury use and release reductions, a baseline must be established in order to measure progress. The details of this baseline will be developed as part of the MSWG's implementation plan. Because there has been a significant reduction in certain sectors such as hospital medical infectious waste incinerators and municipal waste combustors as well as a reduction in product usage, it will be difficult to obtain additional reductions if a fairly recent baseline is used. Therefore, a baseline may be used that is similar to that set by the EPA Bi-National Strategy of 1990 to continue to work on achieving 90% reduction (which is beyond the Bi-National Strategy goals). For coal-fired EGUs, the baseline of 90% reduction by 2015 will mirror the baseline that will be a part of the regulations being developed for this sector as directed by Governor Granholm in her letter to MDEQ Director Chester (see **Appendix E**).

ACTION STEPS:

3.1) **ALLOCATE SUFFICIENT RESOURCES TO CREATE DETAILED SPECIATED MERCURY AIR EMISSIONS INVENTORIES AND INVENTORIES OF MERCURY RELEASES TO OTHER MEDIA, MONITOR, TRACK AND REPORT REDUCTIONS OVER TIME.**

3.2) **DEVELOP A TRACKING DATABASE TO EVALUATE AND REPORT THE PROGRESS FOR IMPLEMENTATION OF THE MDEQ MERCURY STRATEGY. A DETAILED BASELINE WILL BE DEVELOPED IN THE IMPLEMENTATION PLAN. SUMMARIZE AND REPORT ON PROGRESS IN 2011 AND 2016.**

10. TIMEFRAME FOR IMPLEMENTATION OF RECOMMENDATIONS AND REVIEW

The 67 action steps will be encompassed in an implementation plan that which will also identify the MDEQ Division(s) and/or Bureau responsible for implementing specific recommendations, tracking and data for completing the task and reporting final outcomes. The goals to guide these efforts will be to reduce anthropogenic mercury use and releases in Michigan 50% by 2010 and 90% by 2015.

An evaluation of the success of the strategy should be made by 2011 with an interim progress report every two years and a full final report in 2016. The full final report will include a progress report on achieving the overarching goal of eliminating anthropogenic mercury use and releases in Michigan as defined in the MDEQ Mercury Strategy Staff Report. This strategy will help assure Michigan's citizens, wildlife, and abundant natural resources are protected from the unwanted impacts of mercury exposure.

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LIST OF APPENDICES

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